Camera-Trapping Manual for the Arabian Leopard

Rodney Jackson, M. Zafar-ul Islam, Ahmad Boug & Abdulla Al Shehri

National Wildlife Research Center, Taif, Saudi Arabia

Saudi Wildlife Authority (SWA), Riyadh, Saudi Arabia

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1.0 Introduction & Purpose of this Manual

This manual has been written to assist the staff of the National Wildlife Research Center (NRWC) to conduct camera-trap surveys of the Critically Endangered Arabian leopard with the primary purpose of (1) determining Presence-Absence (detection-non-detection) of leopards across the range, followed by (2) intensive camera-trapping in selected areas in order to establish population size and density where this is feasible. Secondary objectives, not addressed in detail in this manual, include a threats-based assessment of each survey area in order to determine and then prioritize conservation actions as recommended under the National Conservation Strategy for the Arabian Leopard (2010). Additional information is contained in the Final Report prepared on the training.

This manual is intended to serve as general guide for planning and executing camera-trap surveys; for more information, practitioners are referred to manuals like Henschel and Ray's (2003) African Leopard Survey and Monitoring Handbook and to Karanth and Nichol's manual on tiger and prey species monitoring for the rationale behind camera-trap theory and survey design. In any case, this manual will need to be periodically updated from the survey results and, we hope, an ever-increasing knowledge of the Arabian leopard's ecology and natural history.

2.0 Status and Ecology of the Arabian Leopard

The Arabian Leopard (*Panthera pardus* ssp. *Nimr)* is listed as Critically Endangered by the IUCN (Mallon et al. 2008), with an effective population of 100-250 across its entire range in the Arabian Peninsula (Box 1). Known as *Al nimr al-arabi*, this leopard subspecies is uniquely small, genetically distinctive, and desert-adapted, endemic to the Arabian Peninsula. It once occupied the mountainous rim of the Arabian Peninsula, albeit at low densities given the harsh environment and its associated limited prey base.

Box 1 – Status of the Arabian leopard in the IUCN Red List (from Strategy for the Conservation of the Leopard in the Arabian Peninsula)

The Arabian leopard (*Panthera pardus nimr*) is listed as Critically Endangered in the IUCN Red List of Threatened Species™ with the following assessment information:
Assessment: CR C2a(i) (version 3.1, 2001)
Year assessed: 1996
Assessor: Cat Specialist Group
Evaluators: Nowell, K., Breitenmoser, U., Breitenmoser, Ch. & Jackson, P.
Justification: The Leopard population of the Arabian peninsula is estimated to number approximately 100 mature individuals, with a declining trend, and no subpopulation estimated to contain more than 50 mature individuals.
History: 1994 – Endangered (Groombridge 1994).

Critically Endangered (CR) indicates that the total population size is estimated to number fewer than 250 mature individuals (C) and a continuing decline observed, projected or inferred in numbers of mature individuals (2), and population structure (a) no subpopulation estimated to contain more than 50 mature individuals (i). For further information see www.redlist.org.

Historically much of the *nimr's* range was located within the Kingdom of Saudi Arabia, which has decreased by some 90% since the 19th Century (Judas et al. 2006). Primary threats to the species are habitat degradation and fragmentation resulting from road or track construction (and which facilitate access for poachers), overgrazing by sheep and goats, construction of new houses (especially in rural areas), urbanization along the Asir Range on the Biljurashi Plateau, and mining or gravel extraction development. Excessive, illegal hunting has greatly depleted numbers of key prey like the Nubian ibex, hyrax, and hare (Al Johany 2007). As a consequence, the leopard has become increasingly dependent upon domestic stock for its subsistence, that in turn leads to retaliatory actions by herders losing animals. Carcasses are poisoned and traps set to remove the predator whenever it is encountered. Although legally protected, law enforcement targeting the Arabian leopard and its prey is insufficient. Finally, there are reports of the sale of leopard furs and occasionally a live animal is sold in the market (for example one cat was sold for $4,800 in the Al Khawbah market in 1997. Leopard fat is valued for its perceived medicinal properties.

Relatively little is known about the ecology and behavior of the Arabian leopard: in fact, most information comes from a single radio-tracking and camera-trap study undertaken in Oman's Jabal Samhan Nature Reserve (Spalton et al. 2006; Spalton and Hikmani 2006).

Al Johany (2007) reported that all 65 leopard sightings he investigated were close to permanent waterholes and at higher elevations in the mountains, generally in rugged and less accessible areas. Johany considered leopards survive in "reasonable numbers," yet an attempt at camera trapping following his 1998-2001 surveys failed to photograph any leopards.

Judas et al (2006) estimated the Saudi Arabian leopard population size at 60-425 individuals within a range of 4,000 – 19,635 km^2, but this was based upon potential rather than occupied habitat. This pattern was confirmed during the surveys undertaken in preparation for intensive camera trapping. While recent reports by local people suggest its presence in a number of areas, actual sightings are rare or very rare and separated by long time intervals. This implies that the remaining population is not only sparse, but highly fragmented. Currently, camera-trapping represents the only available method for accurately mapping the cat's present range and determining numbers in selected areas. Fecal genotyping is another potential approach, but until procedures for gathering 50 or more scats are developed, population size will be difficult to establish using this non-invasive technique (Perez et al. 2006). Nevertheless, it is strongly recommended that NWRC investigate further, since a combination of photographic and genetic survey techniques can be expected to produce the best overall results.

3.0 What Type of Surveys are Most Appropriate?

As noted above, almost nothing is known about the population status or distribution of the Arabian leopard in Saudi Arabia (Judas et al. 2006, Conservation Strategy Plan 2010). Filling these gaps will require a staged approach, whereby areas with confirmed (recent)records are first field-checked in order to update information contained in the 2006 IUCN Cat Specialist Group Special Issue No. 1 (Spalton and Hikmani, 2006, Figure 1; Judas et al. 2006). The second step would entail more intensive, site-specific field surveys, embracing camera-trapping and fecal genotyping,

targeting areas holding the highest potential for harboring a resident and/or breeding leopard population (i.e., areas with little human activity and containing topographically steep or strongly broken habitat).

The National Conservation Strategy (2010) called for each Member Country to establish **National Survey and Monitoring Programs** to assess known and possible existing Arabian leopard populations and potential recovery sites. The plan called for presence/absence surveys and reports to be completed by 2010, using *Rapid Assessment Surveys* (RAS; Box 3, reproduced below) in all areas with possible but unconfirmed leopard presence. Key sites should be defined through interviews, surveys, and data collection in the areas with probable leopard presence, followed by camera trapping and other techniques in those areas with identified leopard presence.

Box 2 - Rapid Assessment Surveys (from Strategy for Conservation of Arabian Leopard, 2010)

A Rapid Assessment Survey (RAS) is a relatively brief, first-order assessment to identify key geographical, ecological and social parameters of a pre-identified area to prioritize and plan future action. A RAS would typically seek to assess:

- Area: extent, terrain, access and logistics;
- Habitats: vegetation and condition;
- Leopard: field signs (tracks, scrapes, scats) local reports (time of last record, frequency of sightings, predation on domestic animals);
- Prey: sightings, field signs, local reports;
- Human population: size, number of settlements, land use, livestock numbers and extent of grazing, local attitudes to leopards.

Approaches used in a RAS are mainly structured interviews of local people/experts, complemented by field excursions. Because of the short time-scale, thorough preparation is important: collate all available data, satellite imagery and maps, prepare questionnaires, and field survey forms.

The NWRC Leopard Project team initiated the RAS process in 2009. Mr. Abdulla Al Shahay interviewed local people, including local herders, honey-gathers, hunters and knowledgeable citizens. Five areas were identified for initial camera-trapping aimed at verifying presence-absence of the leopard in Saudi Arabia:

1. An Namas area (Tanumah 185700N 421100E at 2782 meters)
2. Al Baha (Jabal Uthrab 194550N 414200E at 2348 m)
3. Jizan (Wadi Lajab 173820N 425720E or Jabal Qahar)
4. Madinah (Jabal Radwa 243000N 381500E at 2282 m)
5. Tabuk (Wadi Qusayb 28.01N 34.37E nearest town is Al Bad near the Jordan border)

Based on interviews, known, reputable or probable sightings made within the last 5-10 years were then tabulated. Desirable information includes the date (month-year) of the report, type of sighting (animal seen, animal shot, carcass found, tracks or feces observed), reliability of the record (i.e., whether it is a first or second hand observation, along with the relative observational skills or observer's knowledge of the leopard's behavior), the location and whenever possible the approximate geographic coordinates of the record.

Presence-Absence Survey using Camera Traps: The next step involves a rapid field assessment and visit to each area for the purposes of conducting a presence-absence survey, or more correctly a detection-non detection survey using a combination of ongoing interviews, sign and camera traps. This type of survey has been termed a Systematic Presence-absence Survey by Henschel and Ray (2003) and Jackson et al. (2005). Presence-absence is best validated through the use of camera traps and/or fecal genetic surveys, since sightings and local reports are highly subject to bias resulting from variation in observation skills, the misidentification of species (or their sign) or uneven interview effort.

However, if presence –absence surveys include camera trapping or fecal genotyping as informational sources, then the abundance information generated will be most helpful in prioritizing those areas meriting more intensive camera trapping where the primary objective is to estimate the total population size and its density. Surveys in which limited camera traps are placed out can provide the following kinds of information:

- Minimum number of individual leopards captured during Survey X between date (1) and date (2)
- Number of captures (all photos) per 100 trap-nights
- Capture frequency = number of nights between successive captures of Species X

Note that you need to adjust the total number of trap-nights by subtracting each night that a trap is known or was judged to be inoperative or malfunctioning, and thus not able for sampling having a probability of detection at zero). In addition, be sure to report the number of falsely-trigged photographs (i.e., images triggered by moving vegetation, the sun or moving shadows across heated rocks).

Population Density Estimates using Camera Traps: These surveys aim to establish the number and density of animals occurring within the study area. Density estimates are reliant upon the ability to identify different individuals . This enables the use of the Capture-Mark-Recapture (CMR) algorithm to estimate population size based on the number of marked individuals released into the population and later recaptured (Nichols 1992):

$$D = N / A(W)$$

where *D* is the resulting leopard density, *N* is the population size computed by CAPTURE, and *A(W)* is the resulting area sampled, including the boundary strip (see section on Data Analysis).

A critical step is to estimate the size of the area being surveyed, since out-lying traps in the network will only sample the edges of those animals largely living outside of the study area. The larger the area surveyed, the smaller the effect of such "edge effect" on the overall observed abundance of leopards and hence the density estimate generated.

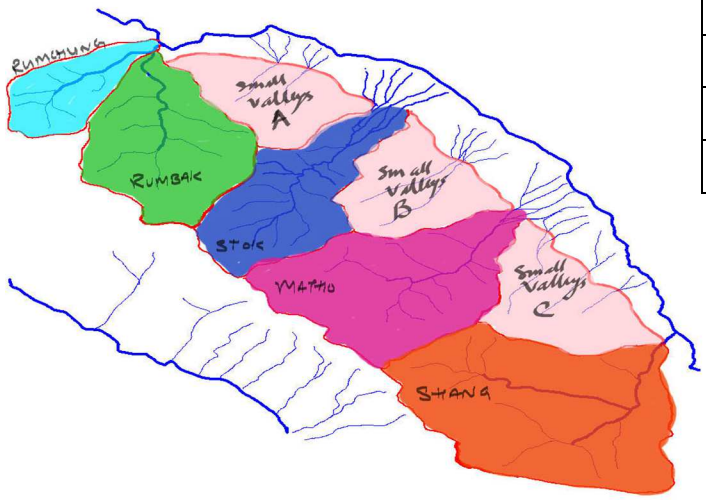
4.0 A Primer on Designing and Conducting Camera Trap Surveys

The ultimate goal in developing a camera-trap CMR survey is to maximize the size of the study area relative to the number of traps and effort available to deploy them within the time frame necessary to meet the assumption of a closed population (i.e., the sampling period should be short enough to ensure that no births, deaths or emigration/immigration occur during the survey). The software program CLOSURE tests for population closure, which typically occurs after periods of 60-80 days (see later).

4.1 Sampling Design Considerations: The first step is to define the extent of the study or survey area. This might be on the basis of a grid (e.g., 10 x 10 km sub-blocks) or using natural features, such as a watershed, where each wadi becomes the sampling unit (Figure 1).

Figure 1: Alternatives for Defining Study Area and Sampling Sub-Blocks

A - Survey Area Subdivided into Watersheds



B - 250 km^2 area divided into 10 X 10 km grids

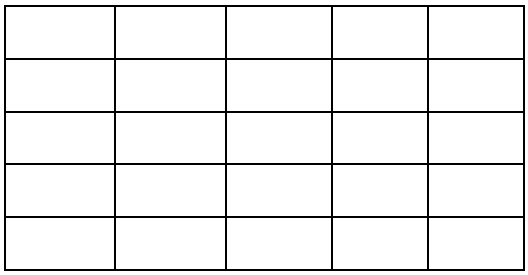
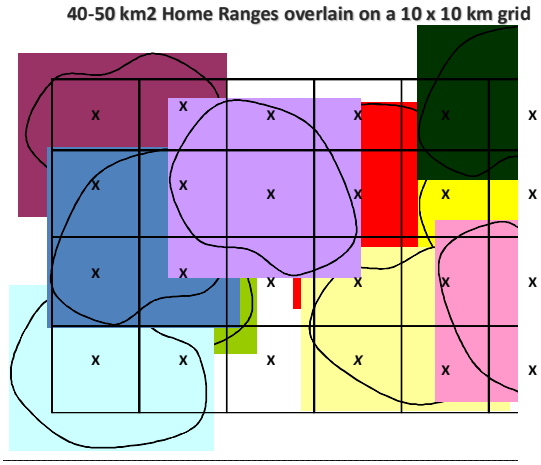


Figure 2: Theoretical Homes Ranges overlain over 10 x 10 km Survey Grids



The size of the study area will depend up such factors as available manpower, logistics (especially within study area access) and the number of camera traps available for use. With a low density species like the Arabian leopard, the 'Golden Rule' is to sample as large an area as possible, although compromises will often have to be made.

We suggest 500 km^2 as the minimum-sized study area, with 800-1,000 km^2 (or more) being ideal, given that adult male leopards home ranges may be 400 km^2 or more in size. This is based on the premise that 500 km^2 may fully enclose a single range only, with the edges of any neighboring cats intruding upon its perimeter (Figure 2).

But again, this will depend upon the availability of camera traps, access / logistics and staff or local guides to monitor them. Since limited numbers of camera traps are usually available, it may be necessary to successively move cameras to new locations over the course of the survey. For example, a team may only have 20 traps. If the goal is to deploy an average trap density of 4 traps per 100 km^2 area, then it would only be possible to sample a 500 km^2 area concurrently, or about 5 survey blocks. One would have to move all traps after 40-50 nights to cover the adjacent survey blocks, with the survey taking a total of 80-100 days to complete. In moving traps from one edge of the survey area trap network to the other, one must ensure there are no gaps within the network for an adult female to remain undetected over the course of the survey (Karanth and others). Given the long interval between leopard visitations to a particular place (Spalton et al. 2006), one must ensure that each trapsite operates for at least 40-50 consecutive nights – thus allowing for only one compete change involving all traps during a 2-3 month survey. Clearly, the more number of traps available, the better!

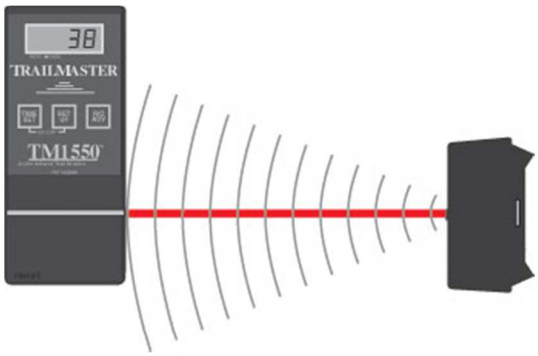
A further complication results from the highly broken terrain typically found across the leopards' range in Saudi Arabia. Given the many possible travel routes, it is exceedingly difficult to predict exactly where a cat would be likely to walk and thus where to place cameras for achieving high capture rates. So again, it may be necessary to install more traps in order to increase their density and the likelihood for photographing a leopard more than once during the survey. We believe that the goal should be 60-80 traps, with the bulk made up of less expensive and visible Bushnell Camo Bone Trophy models. These are fast to set, especially in areas with trees, and far easier to hide than the TrailMaster units.

We also recommend that the team use a GPS to map the vehicle and foot access routes to camera trap sites, especially those in more remote places and monitored by more than one individual.

4.2 Camera-trap Equipment: The Arabian Leopard Project is currently using three different makes of remote camera-traps employing the two basic types of sensors, namely Active Infrared or AIR in which an invisible beam of light has to be broken for a picture to be taken, and the Passive Infrared or PIR system which detects "heat-in-motion." These are illustrated on the following page; for more information on how each system works, see the PowerPoint presentation given at the workshop as well as the manufacturer's instruction manual.

The Active Infrared TrailMaster™ system consists of the following items:

- TM 1550 Monitor (transmitter & receiver)



- TM 35-D10 Camera Kit (digital)

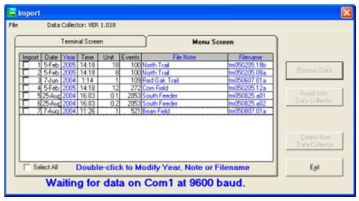
- TM Multi-camera Trigger II

- Cables

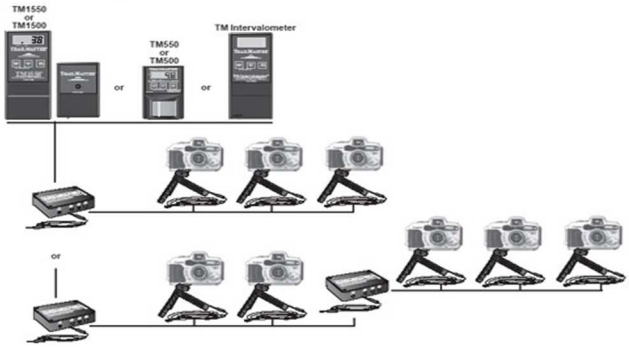
Optional Items include:
TM Data Collector II (optional)

TM Intervalometer (optional)

TM StatPack (optional statistical analysis of events and images)



Trailmaster allows one to have three (or more) Canon D10 digital cameras triggered by connecting cables to one or two multi-triggers, as shown in the diagram opposite. This system is by far the more difficult of the three units to set.



The other two camera-traps, Reconyx™ and Bushnell™ utilize passive infrared (PIR) sensors to trigger their built-in camera. This sensor covers a far wider zone of detection than the TrailMaster's narrow, straight beam of infrared light (which can target specific sized animals (by height and body bulk). By contrast, the PIR sensors are triggered by any small and large animals moving through the detector's cone-like area of sensitivity. Both models are similarly sized compact units which are easy to set, as they lack external cabling like the TrailMaster 1550.

The Reconyx Hyperfire HC500 low-glow camera is exceptionally fast, taking up to 2 images per second in near video mode with a resolution of 3.1 megapixels, and comes with a mapping program.

The Bushnell, at less than half the price of a Reconyx, is more suitable for deployment in places where there are more people, and disturbance or theft become important issues. It can record video and takes up to 3 images per event like the Reconyx (see PowerPoint presentation for details).

Camouflaged and non-camouflaged Bushnell camera-traps

Both Reconyx and Bushnell operate silently, the only indication that a photograph is being taken is a low reddish glow from the LEDs at night. Battery life in the Reconyx HC500 varies according to battery type: it is rated to give 40,000-50,000 images on an Energizer Ultimate Lithium battery, and 20,000-30,000 photos using 1.5v AA Alkaline or AA Rechargeable Nickel-Metal Hydride (NiMH) 1.2v 2600 MaH batteries (at temperatures above 21°C and with equal numbers of day and night images). Battery performance is affected by camera settings, animal activity, make of battery and ambient temperatures.

4.3 Duration of Camera Trap Surveys: As noted earlier, given the Arabian leopard's rarity, apparently large home ranges and elusive behavior, it is recommended that camera traps be operational and in place for long enough to obtain 2-3 repeat visitations by resident animals. Spalton et al. (2006) found that leopard visits to his eight permanent camera traps occurred on average every 29 days (range 19-43). Thus, the survey should operate over a period of at least 84-100 days or 12-14 consecutive weeks.

4.4 Selection of Camera Trap Sites: Box 3 suggests the kind of places and features where leopards are most likely to be photo-trapped.

Box 3: Criteria for Camera-trap Site Selection

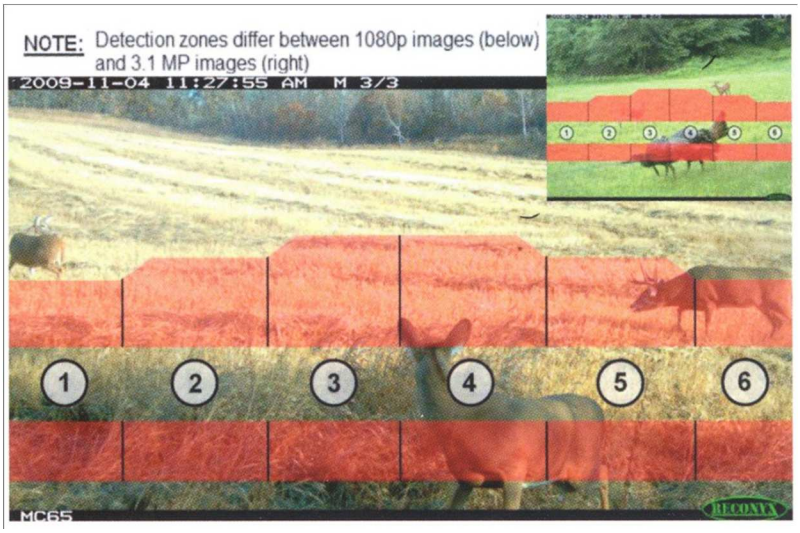
- In the general vicinity of a reliable and recent report (less than 2 months to one year old, and in decreasing order, from a confirmed sighting – alive or dead – to tracks, and vocalizations)
- Well-defined, steeply-sloped and narrow ridges at elevations above 1,000 m (preferably above 1,800 - 2,000 meters)
- Promontories, peaks and high view or vantage points
- Wadi's with seasonal or permanent water which are little visited or disturbed by humans
- Areas where ibex can be sighted (preferable in groups of 5-20 individuals) rather than one or two individuals
- Along narrow cliff ledges in areas with ibex and/or robust populations of hyrax, where hunting /poaching pressures are limited
- Rocky areas with an abundance of caves or overhangs for cover or dens, and with year-round water
- Areas little grazed by domestic livestock (however, livestock may represent an important food source for the Arabian leopard)
- Funnel points between isolated massifs (e.g., Jabal Asraf)

Maximizing the likelihood of photographing a leopard is by far the single most important action that the survey team can take. *It is imperative that all camera traps* to be located in places which maximize the chances of "capturing" any leopard that may happen to visit the immediate area during the course of the survey. This means that all traps must be placed along those features used frequently by the Arabian leopard for moving about their large home range. Based on studies in Oman, leopard home ranges are estimated at some 400 km^2 for adult males and 200 km^2 for females (after cubs have grown, become more mobile and less demanding in terms of food). Of course, these may vary widely depending upon the available prey base, the extent of preferred habitat and degree of human disturbance.

4.5 Details of Sensor Operation and Placement:

Figure 3 indicates how the Reconyx passive infrared camera-trap sensors "heat –in-motion". Differences in heat and motion are detected by comparing infrared wavelengths along two horizontal detection bands as well as six zones (1-6) within each band. Detection range depends upon the difference between ambient temperature and that of the animal, but it is up to 30 m (with nighttime infrared illumination being limited to half this distance. Range in Bushnell is similar.

Figure 3: Reconyx Hyperfire Motion Detector



Once the camera is in place, use the "Walktest" mode to aim it correctly. As you walk in front of it, the red walktest light will blink indicating a motion event. Reconyx has a 40° field of view. It can capture images up to 30 meters (daytime only) or the infrared LED's can illuminate up to a distance of 15 m at night.

Figure 4 indicates how to align the transmitter and receiver units of the TrailMaster 1550 active infrared system. Since the cameras are linked to the receiver or multi-trigger by cable, they can be placed anywhere that is best to obtain detailed photographs of passing animals.

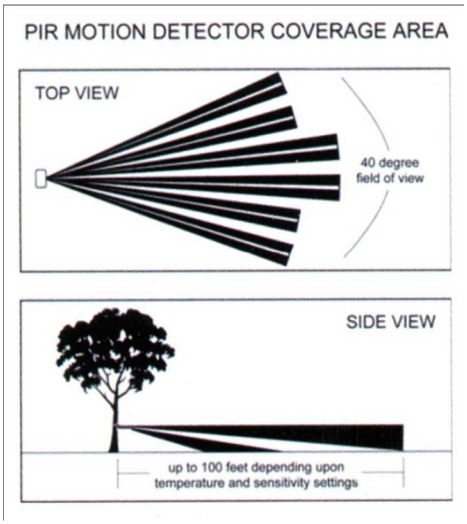
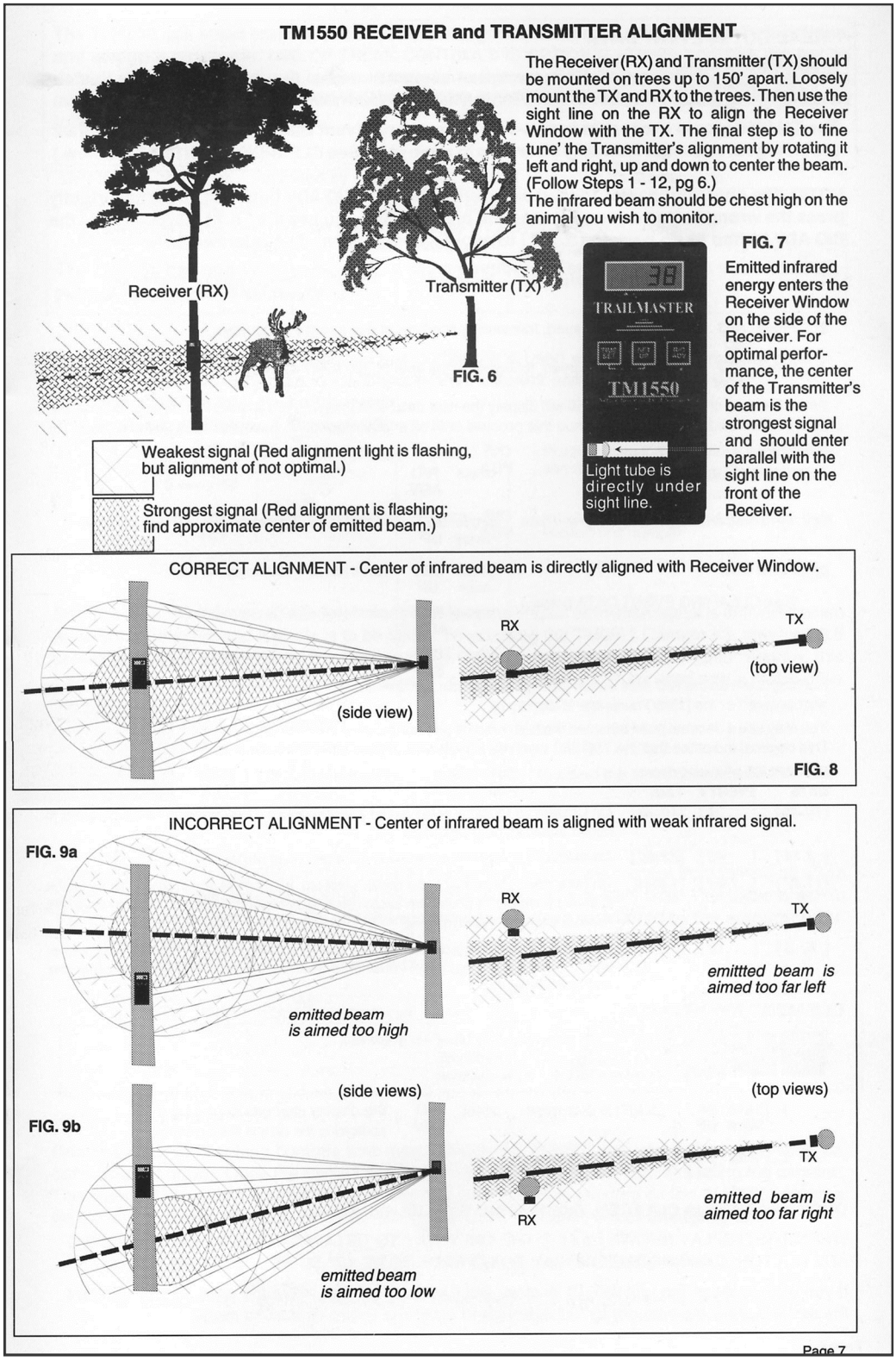
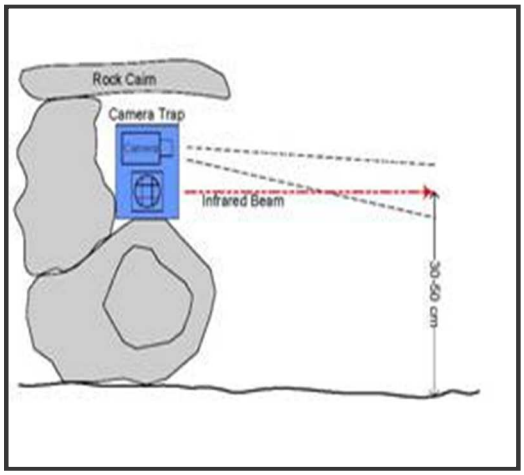

PIR MOTION DETECTOR COVERAGE AREA
TOP VIEW
40 degree field of view
SIDE VIEW
up to 100 feet depending upon temperature and sensitivity settings

Figure 4: Receiver and Transmitter Alignment in the TrailMaster 1500


TM1550 RECEIVER and TRANSMITTER ALIGNMENT
The Receiver (RX) and Transmitter (TX) should be mounted on trees up to 150' apart. Loosely mount the TX and RX to the trees. Then use the sight line on the RX to align the Receiver Window with the TX. The final step is to 'fine tune' the Transmitter's alignment by rotating it left and right, up and down to center the beam. (Follow Steps 1 - 12, pg 6.)
The infrared beam should be chest high on the animal you wish to monitor.
Receiver (RX)
Transmitter (TX)
FIG. 6
Weakest signal (Red alignment light is flashing, but alignment of not optimal.)
Strongest signal (Red alignment is flashing; find approximate center of emitted beam.)
FIG. 7
TRAILMASTER
TM1550
Light tube is directly under sight line.
Emitted infrared energy enters the Receiver Window on the side of the Receiver. For optimal performance, the center of the Transmitter's beam is the strongest signal and should enter parallel with the sight line on the front of the Receiver.
CORRECT ALIGNMENT - Center of infrared beam is directly aligned with Receiver Window.
(side view)
RX
TX
(top view)
FIG. 8
INCORRECT ALIGNMENT - Center of infrared beam is aligned with weak infrared signal.
FIG. 9a
emitted beam is aimed too high
RX
TX
emittted beam is aimed too far left
(side views)
(top views)
FIG. 9b
emitted beam is aimed too low
RX
TX
emitted beam is aimed too far right
Page 7

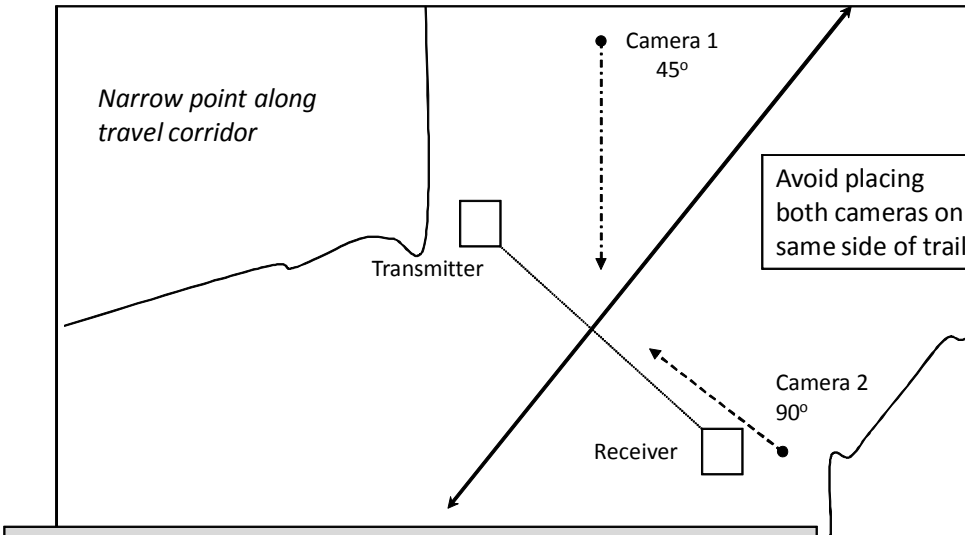
The optimal height for the TrailMaster 1550 sensor is 35-40 cm above ground level, such that the beam is broken by the leopard's body rather than its limbs (see Figure 5). The same holds for Reconyx and Bushnell camera-traps, since body temperature of the abdomen and chest should be higher than the animal's extremities.

Figure 5: Sensor Alignment including TM1550 Active Sensor for a snow leopard, Jackson et al 2005).



Regardless of whether active or passive trail monitors are used, each camera trap should be placed 2-4 meters from where you expect the leopard to walk (Figure 6).

Figure 6: Suggested TrailMaster 1550 Active Infrared Camera Trap Set-up



Leopard travel path – avoid placing cameras directly head-on *e.g.* parallel to the trail. Rather angle each one a little for a lateral view as well as the frontal or facial view of the cat, as indicated by the dotted lines. Note: if trail is wide enough, place both cameras at a 90° angle to the travel path at distance of 2-3 meters from the center of the trail. We recommend that TrailMaster cameras be angled slightly, giving the camera more time to initialize and take a photograph

The goal is to obtain a full-body photograph of the leopard from either side of its body, so that it can be definitively identified (at first capture) based on the pelage pattern along its flanks. Too close and you will capture only part of the leopard's body, too far and the image will be too coarse for identification (especially when using the lower resolution Bushnell or Reconyx camera traps).

In the case of the TrailMaster, you will place two cameras on opposite sides of the travel pathway at right-angles (90 degrees) such that they are facing one another (Figure 6). Where the pathway is narrow, or where a animal would walk quickly, the cameras should be placed at 45° in order to give time for the camera to "wake-up" and capture at least one image (2-3 photographs are clearly preferable!).

For the rapidly firing Reconyx or Bushnell PIR sensors, we need to deploy only one unit at each site for the following reason: These cameras can be set to take up to three (3) images for each movement detected (termed an event), with two to five (maximum) seconds delay between each triggering, thus allowing for multiple sets of pictures from any single visit. Since these camera-traps respond extremely rapidly (Reconyx 0.91; Bushnell 1.38 seconds), they can be placed at right-angles to the path of travel, in order to capture a full side view of the animal. However, don't place it too close in the case of the Bushnell camera-trap, for the string LEDs leave a featureless white image.

By placing the camera at a place of special interest (e.g., a waterhole, leopard scrape or mark, rock scented with Calvin Klein, or by deploying a call box), we are seeking to get the animal's attention for several seconds or minutes – thus giving it time to move around and change its body position with respect to the camera-trap. In Mongolia, we found that both sides of snow leopards were often represented if we placed our PIR traps at a fresh scrape or similar social marking site. One could also hang a chicken wing from a nearby tree branch, with the expectation that a curious leopard will investigate if it is moving about in the wind. As long as the effort and bait or attractant protocols are standardized, it should not have a major effect on the sampling strategy or have statistical implications under any capture-recapture survey.

There should be no vegetation within the zone off detection, since this triggers the sensor leading to numerous false events (i.e., no animal present). Secondly, the sensors should face to the north, rather than east or west, because these aspects have much more infrared light (which may also thus lead to false triggering and decreased memory space for storing images from desired animal-triggered events).

Cameras need to be sufficiently well hidden (i.e., camouflaged) so as to reduce the potential of theft or disturbance by humans visiting the site (see later). In areas with baboons, both cameras and cables should be carefully concealed in order to preclude these primates from shifting or removing them, thus rendering the setup nonfunctional. Therefore, more frequent checks are warranted in areas supporting baboons, especially for camera traps set along travel routes used by this species. On the other hand, baboon vigilance behavior may provide an indicator of leopard predation: troops that sleep on steep terrain are likely under greater predatory pressure than those choosing to sleep in more gentle and accessible places.

Along the Biljurushi Escarpment , the best trap sites appear to be above along the middle slopes in areas sufficiently removed from the intensive urbanization found along the top of the plateau or in the low-lying agricultural areas along the plains stretching to the Red Sea. In the last few decades numerous houses (along with dirt tracks or narrow paved roads) have been constructed in many areas. These have the effect of fragmenting potential leopard habitat, and making it more difficult to find areas large enough to support more than one or two contiguous home ranges.

4.6 Other Reminders on Setting Camera Traps: Make sure that you go into the field properly equipped prepared. Be sure to check that the equipment is working properly. Appendix 1 lists both essential and recommended equipment along with important pre-survey preparation reminders.

Follow the instructions (and illustrations) provided in the handouts describing the three makes of camera traps (Appendices 2-A to 2-C). For additional information, consult the camera trap manual prepared for leopards (Henschel and Ray 2003) or snow leopards (Jackson et al. 2005), since PIR (Passive Infrared) and AIR (Active Infrared) systems function in a standard manner irrespective of the targeted species. The key points to remember are summarized in Box 4.

Box 4: Important Tips when Setting Camera Traps.

- Never point the PIR sensor (or TM 1550 receiver window) toward the rising or setting sun, especially when it is low on the horizon. The reason being the high incidence of infrared light at these times which are likely to repeatedly set the camera off (false triggering). If there is no choice but to face sensors to the east or west, try to use a nearby hillslope or large rock to prevent the sun's beam from falling on the unit when it is lowest on the horizon.
- Make sure there is no vegetation within the sensing zone that could move in the wind, for this will set the cameras off (i.e., "heat in motion" for PIR sensors and blocking of the fixed infrared beam for the Active Infrared TM1550 sensor).
- Make sure the TrailMaster's transmitter and receiver are absolutely stable and also cannot be moved by wind: this too will trigger the device. The same applies to Bushnell and Reconyx, which are also sensitive to movement of vegetation within their zones of detection. For these reasons, camera traps should <u>never</u> be secured to small trees that can be moved by wind, nor should they face plants (bushes, grasses or tree branches) which are prone to wind movement. All vegetation has to be removed from the TM1550 beam or the general area of the passive Infrared camera's sensor (see the manufacturer's manual for details).
- Place cameras no closer than 2 meters from where you expect the leopard to trigger the camera (this will give a blurred image with only part of the body featured) and no further than 4 meters (as this will give an image that's likely too small to reveal much detail about the leopard's spotting pattern.
- Try to place the camera(s) at places where the leopard is likely to be moving more slowly or can be expected to linger for a few seconds or minutes; if necessary get its attention by using Calvin Klein scent and hanging chicken wings in a nearby tree.
- Pay attention to details and take your time in setting up camera traps – double check that the settings are correct (see instructions) and that the unit has been activated before leaving the site. Make sure that you have installed an empty SD memory card.

4.7 <u>Camouflaging Camera Traps</u>: All camera-traps should be camouflaged using special camouflage tape (see Final Report for details). It may also be possible to use local materials to help conceal camera traps and sensors. For example, if these are deployed along wadis (which constitute movement corridors for many wildlife species), one could use various items of litter (especially paper or plastic packaging) to partially cover camera. Or take advantage of the fact that people often discard clothing by hanging these in bushes, using the clothing in front of the camera with holes for the sensor and the infrared LEDs.

4.8 Protecting Camera Traps from Theft or Damage: Security is a major concern, especially given the proximity of most photo trapping sites to human settlements. The support of local people is critical, requiring dialog and confidence building with local tribal leaders, and supported by a general public awareness raising program. In some instances, such as Jebel Radwa, it may not be possible to leave without high risk of them being removed or stolen. The use of less intrusive camera traps like Bushnell or Reconyx over the TrailMaster 1550, as well as placing cameras away from trails frequented by local people may also be required, depending upon conditions in the survey area. Given the fact that wadi's represent good trapping locations, a local person could be hired to place the trap out each afternoon and remove it the next morning so that it is displayed during the most vulnerable time.

It is recommended that the NWRC purchase the special optional tamper-proof metal security enclosures which are available from each manufacturer, or make their own based on proven designs. Similarly, Master Python locks can be used to secure each unit to a tree or an post imbedded in concrete (useful in the case of permanent trap sites). Installing the TrailMaster within protective cases is currently being investigated, but it will be virtually impossible to protect any device from a person determined to remove or damage it. Having said this, it is still worth labeling each camera indicating the owner of thee camera traps and purpose of the study; for example, "Property of the Leopard Research Project of NWRC-NWCD - Please do disturb. Please contact <name> <Phone#>."

4.9 Other Recommendations: As noted earlier, camera traps should be left out as long as possible, in order to increase the chance for both new captures and recaptures of known individuals. Most camera-trap surveys are limited to 40-70 days in order to avoid violating the population closure assumption (Otis et al. 1978, White et al. 1982). However, from local reports and research by Spalton and associates in Oman, it is clear that leopards revisit sites only after long periods of time (up to 49 days between a visit).

4.10 Sensor Settings**:** Instructions on operating TrailMaster 1550 camera-traps are listed in Appendix 2-A, with summary instructions appearing in Appendix 2-B. Whenever possible, the camera-traps should have uniform settings, so that they can be considered equal in terms of their ability to detect visitations by leopards and capture images for identification. Recommended settings and operating instructions for Reconyx and Bushnell cameras is provided in Appendix 2-C.

Box 5 summarizes the suggested settings for the TrailMaster 1550 monitor and camera. Note that these settings may need to be adjusted later depending upon results of the pilot phase. For example, camera could be set to capture a wider range of wildlife species, to take fewer images at each event in order to extend battery life or to increase the time delay between photographs.

Box 5 – Recommended Settings for TrailMaster 1550 Active Infrared Trail Monitor

Active period = 24 hours (day and night)

TrailMaster 1550:
-P value = 5 Camera Delay (cd) = 0.2 (6 seconds)
Camera Time (shutter activation signal, Ct) = 5 seconds
Camera Alive (Ca) = 1.0 (hour) Frame limit (L) = nL (no limit)
Passcode = 2000

Canon D10 Camera:
Image Size = M1 or 8 megapixel, 3264 x 2448, fine setting
Camera = P (Program Mode), continuous mode
ASA = 400
Metering mode = center-weighted average center-weighted average
AF Frame = "Center" (place at center of frame and infrared beam to capture animal)
Servo AF = OFF
AF-Point Zoom = OFF (after camera set at desired zoom level if necessary)
AF-assist beam = Probably best set to OFF, as it will almost certain trouble shy species like nimr (for details see below, under manual focus)
Red-eye correction = OFF
Red-Eye Lamp = OFF
Date Stamp= Date & Time (facilitates matching images & events)
Mute = OFF (Use ON if you want to draw animal's attention)
LCD Brightness = reduce to ½
File Numbering = Continuous
Flash Mode = auto ON; Do Not set on slow synchro.

Box 6 shows recommended settings for Bushnell and Reconyx camera-traps.

Box 6 – Recommended Settings for the Bushnell and Reconyx Passive Infrared Sensors

Active Period = 24 hours (day and night)

Reconyx: Check for number of images taken or percent of memory remaining
Trigger = On (high sensitivity) 3 images per event
Picture interval (Camera delay) = 2-3 seconds
Quiet period = no delay Time Lapse = Off
Resolution = 1080p
Set the battery type installed (requires 12)
Note: Reconyx cameras will self-arm from the "WalkTest" mode after a two minute period in which it does not detect any motion.

Bushnell Trophy Cam: Check for number of images taken; remaining battery life (indicator bars upper right)
Camera Mode Image Size = 5 M pixel
Camera Number = 3 Photo (per event)
Picture interval = 2-3 seconds Interval = 0 sec
Sensor level = Normal Time Stamp = On
Requires 8 AA batteries
Note: The Bushnell camera has to be switched from the "setup" position to "ON" for it to be activated.

Lithium or rechargeable NiMH batteries provide the Reconyx with the longest life, the latter being more economical in the long-run.

4.11 Monitoring of Camera-Traps**:** Cameras should be checked every 7-15 days depending upon the site and its security from disturbance by people. One also needs to check battery voltage and remaining memory card capacity if the camera-traps have been out for long.

The voltage should be 1.45 – 1.5 for alkaline or lithium batteries; change them if it drops below 1.40. Check using the built-in camera-trap indicator (Reconyx will show the percent % of battery life remaining, the Bushnell and Canon D10 a simple barred indicator in the upper right of the LCD window).

TM1550 – batteries should last at least 8 months; the Canon D10 camera is rated to give up to 1.5 – 2 months, depending upon the number of images and flash use (please validate this estimate). Bushnell and Reconyx PIR sensors have an estimated life of at least 4-6 months, and probably longer depending upon the number of images accrued. In any case, it is wise policy to check battery gauges during each visit to verify sufficient power remains; if it falls to 2 bars, replace the AA batteries. Remember that any period that a camera is inoperative, for any reason whatsoever, will violate the assumption of equal trapping probability among the deployed network of camera-traps.

4.12 False Images: Record the number of falsely-triggered images taken during each trapping occasion, and use this to adjust downward the number of operational trap-nights. False images are those ones triggered by non-animal causes, like moving branches or when a gust of wind moves the sensor itself. Zoom in on the image, to search for any mammal, bird or reptile animal of mouse size or larger. False images will not have any animal in the frame. Tip: check the preceding and succeeding images to see if these were taken within the same time period and have any animals present.

False images can be erased from card memory, but before doing so, follow the instructions under the "troubleshooting" instructions given in the manufacturer's manual.

4.13 Camera Flash and related Visibility Profile: The TM 1550 Canon D10 has a flash which can result in some animals becoming trap-shy and possibly avoiding the site, in effect reducing their chances of being re-captures. While extending, the camera's lens makes a slight noise, which might attract the attention of the animal, and which in turn may turn its head toward to the camera. This could, in fact, be an advantage leading to a more attractive photograph. In any case, the TM1550 is also vulnerable to theft on account of the number of equipment items, their coloring, and the black cabling than the lower visibility PIR models. The Reconyx HC500 and Bushnell Trophy Cam are termed "low glow" camera-traps, because of the faint red glow seen from LEDs at night; these should not disturb wildlife, and the unit's operation is soundless. Appendix 3-A provides the data form to be used at the time of camera station setup, while

Appendix 3-B is the standard form to be used during site monitoring visitations (number of images taken) and for recording such supporting information as new animal sign since set-up , battery status, any equipment malfunctions, and any changes made to camera placement or operational settings. Information from the set-up form can be used to trouble shoot problems later, as well as supporting efforts related to the identification of individual leopards.

It is important to note the following information on Form 3-A: compass direction in which the camera-trap is facing (in degrees), distance between the senor and the project travel path of the animal, height of the sensor above ground; number of “test images” saved on the memory card. It helps to take an image and then examine it on the Cuddeback SD card viewer in order to make sure the camera will properly frame the image.

5.0 Data Analysis

5.1 Capture-Mark-Recapture (CMR) Analysis**:** The Indian biologist, Ullas Karanth was the first to use photography and camera traps to estimate population size in tigers (Karanth 1995, Karanth and Nichols 1998). For an overview of how CMR works, see Nichols (1992), provided with the workshop handouts.

CAPTURE derives its population estimate from the proportion of marked (i.e. previously caught & identified) to unmarked (i.e., newly captured) individuals across consecutive trapping sessions, also known as sampling occasions. At the end of the study, all images from each visitation (or event) are examined and each individual leopard identified (see below). The data is then collated into capture histories contained within a 'X matrix', an example of which is shown in Figure 7.

Figure 7: Example of a Capture History involving 5 snow leopards and 9 trapping occasions.

Example of a Capture History Table

Cat ID No.	Age Class & Sex	Capture History by Sampling Occasion1 (n=9) (0 = no visit; 1 = visit detected)								
		1	2	3	4	5	6	7	8	9
1	Adult Male	1	1	1	0	1	1	0	1	1
2	Adult Female	0	1	1	1	0	0	0	1	1
3	Sub-adult	0	1	1	0	1	0	0	1	0
4	Sub-adult Male	0	0	0	1	0	0	0	0	1
5	Adult/Female (+ 2 cubs)	1	0	0	0	1	0	0	0	0
6	Adult	0	0	0	0	0	0	0	0	1

Each sampling occasion may vary in length from 1-7 or more days

In their tiger study, Karanth and Nichols (1998) computed the width of this added boundary strip using the "mean maximum (linear) distance moved" by the tigers that they captured on more than one occasion. Boundary strip width was then defined as being half the mean maximum distance moved according to the following equation:

$$W = (\Sigma\, d / m) / 2$$

where *W* is the resulting boundary strip width, *d* is the maximum distance moved, and *m* is the number of maximum distances compared. Then the boundary strip of width *W* must be added around the perimeter of the area covered by camera traps, to obtain the sampled area. The number of individuals estimated by CAPTURE can then be converted to a density estimated using the formula shown on page 4 of this manual.

Key assumptions that the CMR study and dataset should meet are as follows:

a) Demographic & geographic closure (no immigration – emigration should occur during survey period, typically lasting 40-60+ days). This may have to be relaxed in the case of the Arabian leopard, given its apparently very low densities.
b) Equal "trappability" or catchability (equal likelihood of capture among all individuals of the population – in other words there should be no trap happy or trap leopards)
c) Each individual is uniquely marked and thus identifiable from all others in population. This assumption can be satisfactorily met.
d) All previously captured individuals can be distinguished from unmarked (non-captured) individuals (i.e. individual identification must be reliably & unambiguously achieved). This is also met, as the cat's spot pattern do not change with age. However, note that both sides of the animal must be photographed for definitive identification.

5.2 Identification of Captured Leopards: All leopards photographed can be identified following procedures described by Henschel and Ray (2003), and available for download from *http://www.savingwildplaces.com/media/file/low-leopard.pdf*.

Figure 8: Identifying Individual Leopards on basis of Lateral Body Spot Patterns.

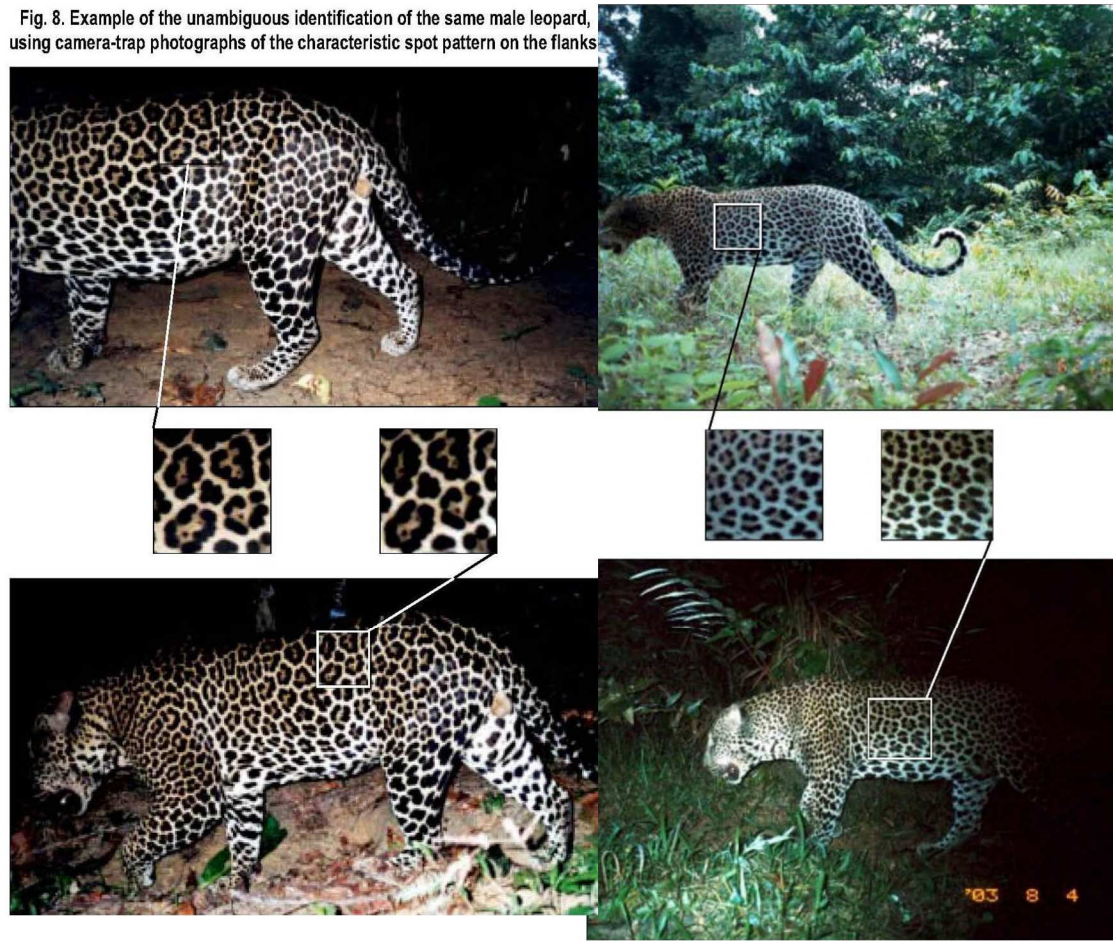


Fig. 8. Example of the unambiguous identification of the same male leopard, using camera-trap photographs of the characteristic spot pattern on the flanks
'03 8 4

Like its African cousin, the Arabian leopard is most easily identified by the spotting pattern found on the left and right flanks of the body as shown in the Figure 8 taken from taken from Henschel and Ray (2003, pages 34-35). The left photograph shows the same individual; the right shows two different individuals (both show left side of the body).

In order to obtain suitable photographs, it is important that the camera be placed 2-3 meters from the place where the leopard would be expected to walk past the camera-trap. Too close, and one loses the full-body image, too far and the spots or rosettes may not be detailed enough for definitive identification at first capture. Two opposing cameras should be deployed at each TrailMaster 1550 camera-trap. Since the Reconyx and Bushnell are set to taken three images at each event with a delay of 2-3 seconds, 3-9 images can reasonably be expected from each visitation as long as traps are set at places where the animal is moving slowly. By deposited some artificial scent directly in front of the camera trap, it can be expected to stop and investigate the unusual odor. Photographs of both sides of the body will result if it turns around, sniffs and scrapes (as was commonly observed with snow leopards for camera traps placed at communal scrape sites (Jackson, personal observation).

Note that it is also possible to sex adults based on body size and the presence of testes. Male leopards have large heads and more robust chests as shown by photographs of captive animals at the NWRC breeding facility in Taif. Semi-automated identification may be facilitated using the pattern software contained in this workshop's CD.

5.3 Data Analysis:

The software program *CloseTest* can be used to test capture-recapture data for closure. It was prepared by Dr. Thomas R. Stanley and Jon D. Richards. For background information, see the paper by Stanley, T.R and K.P. Burnham. 1999. A closure test for time-specific capture-recapture data. Environmental and Ecological Statistics 6:197-209. CloseTest is available for download from the internet at the US Geological Survey site dedicated to CAPTURE.

Analysis of camera-trap data is done using the software program CAPTURE, which with its User Manual, is available for download from: www.cnr.colostate.edu/~gwhite/software.html Appendix 4 provides annotated details of how to structure CAPTURE input files as unformatted text or an ASCII file. Capture History datasets can be run interactively and on-line by "copying & pasting" in data into a web "window" http://www.mbr-pwrc.usgs.gov/software/capture.html

I recommend that the capture history information be grouped into occasions totaling 3-5 days in order to increase capture probabilities closer to the desired level of 0.20 or greater. This can be achieved by running CAPTURE with different duration occasions (or sessions), such as 3-day intervals, 5-day intervals, and 7-day intervals.

Using the capture matrix, software CAPTURE then generates the following matrix for analysis, statistical assessment and model fitting.

Hypothetical Summary Capture-Mark-Recapture Statistics (derived from previous table)									
Parameter	**Sampling Occasion**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Total number of animals caught (photographed) during each occasion.	2	3	3	2	3	1	0	3	4
Total number of unique individuals caught previously to this trapping interval.	0	2	4	4	5	5	5	5	5
Number of newly caught individuals (i.e. previously unmarked and first observed in this occasion).	2	2	0	1	0	0	0	0	1

CAPTURE then attempts to fit the inputted dataset with one of seven models described in the Figure 9 below. The simplest model $M_{(o)}$ assumes no differences in capture probability between individual leopards and sampling occasions. The second, Model $M_{(h)}$ tests for differences in capture probabilities between individuals under the assumption that different age classes or sex may differ in their susceptibility to being captured. Other models look for differences in behavior $M_{(b)}$ and time $M_{(t)}$ or a combination of these. For details, please consult CAPTURE's User Manual (provided on the workshop CD), as well as the following publications:

Rexstad, E., and K. P. Burnham. 1991. User's guide for Interactive Program CAPTURE. Colorado Cooperative Fish and Wildlife Research Unit. Colorado State University, Fort Collins, Colorado.

Otis, D.L., K.P. Burnham, G.C. White and D.R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monograph 62:135 pages.

White, G.C., D.R. Anderson, K.P. Burnham and D.L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA 8787-NERP, Los Alamos, New Mexico. 235 pages

These documents will assist you in correctly interpreting the outputs from CAPURE, which includes the following specific tests for model validation.

CAPTURE gives a value of 1.00 to the best model, but the selection values are relative so there is some room for interpretation. However, Otis et al. (1978) recommend selecting one with a value ≥ 0.90 and which has acceptable goodness of fit.

Figure 9: Summary of Closed Population Models Evaluated by CAPTURE (From Jackson et al. 2005)

Model		Sources of variations in capture probabilities	Appropriate Estimator	Comments
Model Mo	Equal or Constant Capture Probability Model	None (i.e., capture probabilities are constant with respect to all factors). Incorporates only 2 parameters (population size & capture probability).	Null (model against which all others can be compared).	Too simplistic for most free-living populations.
Model Mh	Heterogeneity Model	Heterogeneity (each individual has its own capture probability which remains constant over sampling period).	Jackknife	Jackknife estimator increases robustness.
Model Mt	Schnabel Model or Variation by time	Time (allows capture probabilities to vary by time only).	Darroch	Very sensitive to behavioral response or innately varying capture probabilities.
Model Mb	Trap Response Model (equivalent to a "removal" model)	Behavior (assumes that on any given trapping occasion, all unmarked individuals have one probability of capture, and all marked individuals another probability of capture).	Zippin	Allows capture probabilities to vary by behavioral response (trap-happy or trap-shy individuals) after first capture.
Model Mtb	Time variation in captures or recaptures	Time & behavior (allows capture & recapture probabilities to vary with time).	None available	Needed for testing relationships between models.
Model Mth	Both time & heterogeneity affect capture probabilities	Time & heterogeneity	None available	Needed for testing relationships between models.
Model Mbh	Behavior & Individual Response Model	Behavior & heterogeneity	Generalized removal	Under this model, each individual has its own probability of first capture.
Model Mtbh	All Effects Model	Time, behavior & heterogeneity	None available	Needed for testing relationships between models.

Figure 10 (from Jackson et al. 2005) summarizes the tests CAPTURE uses for determining which model best fits the dataset. Tests 1-3 compare the relative fit of the null model with the time, heterogeneity and behavior models respectively. Tests 4 -7 judge the Goodness-of-Fit of these models and compares the relative fit of the heterogeneity and behavior-heterogeneity models. While this table offers guidance to determining whether to accept or reject the respective null hypotheses, I recommend becoming familiar with the underlying theory by reading the monographs by Otis or White et al. (1978, 1982) or consulting a statistician.

Figure 10: Specific Tests of Assumptions used in Model Selection Procedure (from Otis et al. 1978):

Test #	Source Variation	Null hypothesis	Alternative hypothesis	Comments
1	Heterogeneity	Model M_o fits data	Model M_h fits data	Examines capture frequencies for evidence of variability among individual capture probabilities.
2	Trap response after 1st capture	Model M_o fits data	Model M_b fits data	Examines gross behavior effects on capture probabilities.
3	Time variation in capture probability	Model M_o fits data	Model M_t fits data	Tests for variation in average daily capture probabilities.
4	Trap response and/or time variation given heterogeneity	Model M_h fits data	Model M_h fails to fit data	If M_h is true model, we expect this test not to reject. Test 1 should favor M_h.
4a	As above	As above	As above	Tests for trap response or time variation or both with large individual recaptures.
5	Heterogeneity and/or time variation given trap response	Model M_b fits data	Model M_b fails to fits data	If M_b represents the best model, we expect this test not to reject. Test 2 should show similar favor.
5a	Heterogeneity and/or time variation using first capture only	First capture probabilities are constant	First capture probabilities vary by time and/or individual	Test identical to goodness of fit test for simple removal model.
5b	Heterogeneity and/or time variation using only recaptures	Recapture probabilities are constant	Recapture probabilities vary by time and/or individual	If M_b is true, then this null hypothesis should not be rejected.
6	Trap response and/or heterogeneity given time variation	Model M_t fits data	Mode M_t fails to fit the data	If M_t is the model, then we would expect this test not to reject; also we expect Model M_o to be rejected in favor or M_t.
7	Trap response given heterogeneity	Model M_h fits data	Model M_{bh} fits the data	This test is useful because if we reject M_h in favor of M_{bh}, the estimator to use is the generalized removal method.

For an example of a Capture-Mark-Recapture study of a rare carnivore, the snow leopard, see Jackson et al. 2005 and 2006.

5.4 Data Management: All information from the field data forms should be entered into Excel files in order to facilitate data analysis. Use of Excel's drop-down lists "options" menu's are highly recommended as this helps standardize data from different observers while reducing the number of errors during the data entry process (see *Create a drop-down list from a range of cells* in Excel).

Digital camera traps (especially those employing PIR sensors) generate an enormous amount of data that can easily overwhelm users. The NWRRC therefore needs to implement a rational and systematic system for retrieving, cataloging, analyzing and reporting on camera trapping results. Data from the TrailMaster sensors can be uploaded to computers dedicated to the Arabian Leopard Project using the TM Data Collector II (with enabling software StatPack and serial port adaptor). StatPack enables the user to annotate images with species names or site-specific information,

analyze temporal data and output 2- or 3-dimensional graphs illustrating the activity periods (by user specified time periods) of camera-trapped wildlife (see TM StatPack User Manual for details).

Capture images from the Reconyx and Bushnell camera traps can be transferred to a computer via built in or USB-attached SD card readers. The resulting information can then be processed using the system recommended by Harris et al. (2010). Data retrieval, image file labeling, storage, and data analysis is a three-step process employing open-source software and software produced by Harris and his associates:

a) The memory card is removed from camera trap, inserted into a computer and moves the files to a temporary location folder, e.g., *Location01Temp*, which contains images taken from the camera trap at Location01.
b) The freeware program ReNamer (Kozlov 2009) is used to rename all files simultaneously in folder *Location01Temp* with the date and time each picture was taken, which solves two problems (a) all files are uniquely labeled by date and time for multiple images from the same location cannot be recorded at precisely the same time), and (b) avoids overwrite previously downloaded files for many cameras (including Bushnell) reset memory cards to zero when files are removed. The file renaming step is repeated for all camera trap sites.
c) One then produces a text file containing all image file information using a single DOS command.

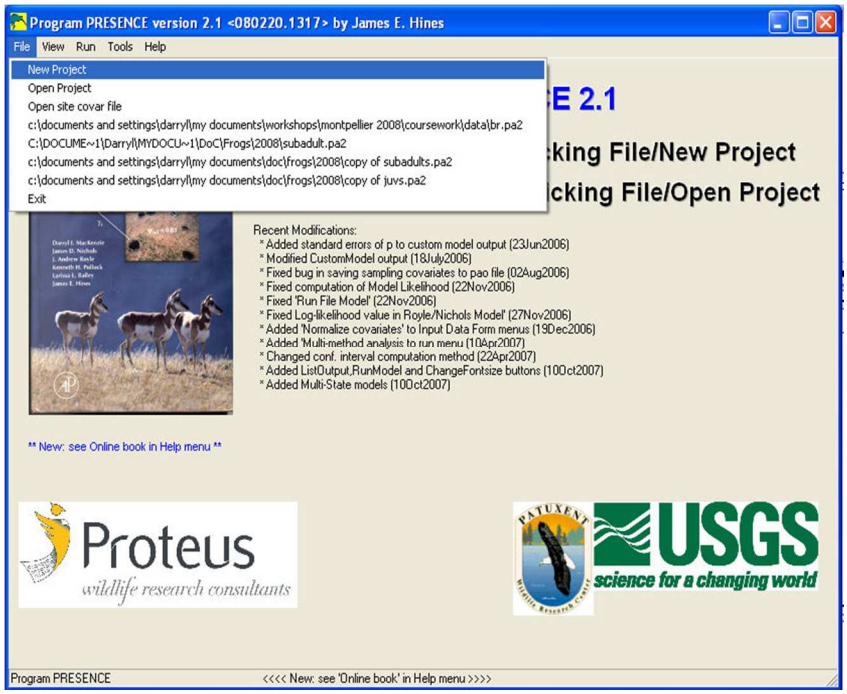
Data analysis is also a two-step process using the two computer programs written by the authors:

a) The first computer program uses the hierarchical text file to assemble a second text file, each of whose lines appear as: *Location Species Year Month Day Hour Minute Second Number-of-Individuals*. This file can be directly imported into a spreadsheet for permanent archiving. Also produced is a third text file that contains a list of locations and species that are used in the analysis. The user edits this file, which includes dummy variables (placeholders) for each location's start and stop date, and UTM coordinates.
b) The second computer program uses the latter two files to produce a full analysis of the camera trap imagery. The output from the analysis is a final text file containing all results, and which can be imported into a spreadsheet program. The output file also provides text that can be directly input to other analysis programs such as PRESENCE, which estimates the proportion of locations occupied by a species.

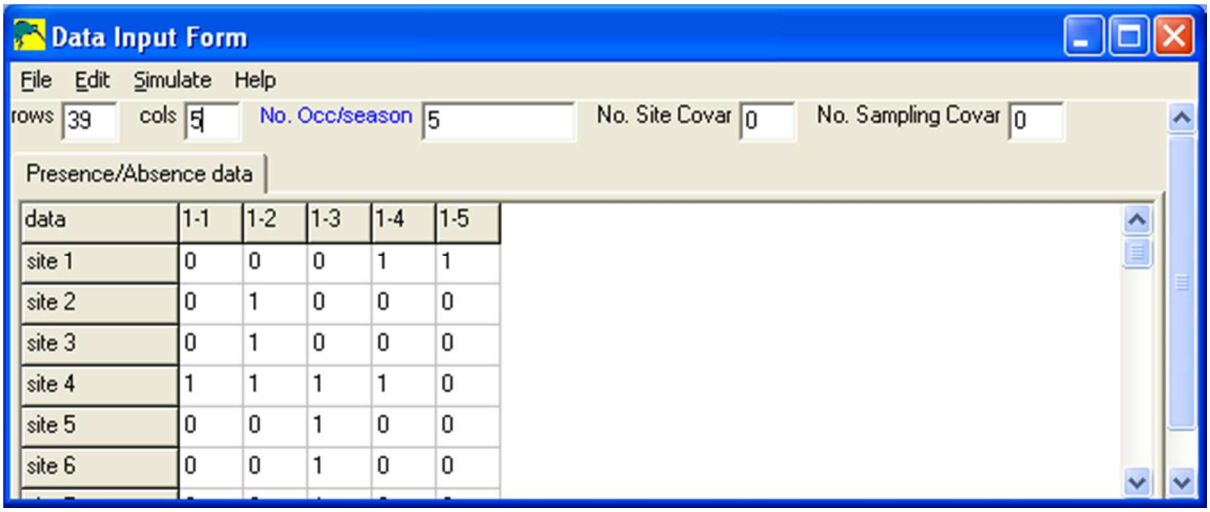
NWRC will need to customize the data processing steps to meet its particular needs and to enable information to be inputted into Excel spreadsheets and standard statistical programs for analysis. Careful and meticulous management of the camera-trap image data base is especially important, regardless of the kind of analysis that is undertaken.

6.0 Deploying Camera traps for Occupancy Surveys

While et al. (1998) reported that the program CAPTURE performs poorly with populations of less than 20 individuals; therefore, given the Arabian leopard's sparse population, it may not be possible to generate a bounded estimate of population size with 95% confidence intervals.


Program PRESENCE version 2.1 <080220.1317> by James E. Hines
File View Run Tools Help
New Project
Open Project
Open site covar file
c:\documents and settings\darryl\my documents\workshops\montpellier 2008\coursework\data\br.pa2
C:\DOCUME~1\Darryl\MYDOCU~1\DoC\Frogs\2008\subadult.pa2
c:\documents and settings\darryl\my documents\doc\frogs\2008\copy of subadults.pa2
c:\documents and settings\darryl\my documents\doc\frogs\2008\copy of juvs.pa2
Exit
E 2.1
king File/New Project
cking File/Open Project
Recent Modifications:
* Added standard errors of p to custom model output (23Jun2006)
* Modified CustomModel output (18July2006)
* Fixed bug in saving sampling covariates to pao file (02Aug2006)
* Fixed computation of Model Likelihood (22Nov2006)
* Fixed 'Run File Model' (22Nov2006)
* Fixed Log-likelihood value in Royle/Nichols Model' (27Nov2006)
* Added 'Normalize covariates' to Input Data Form menus (19Dec2006)
* Added 'Multi-method analysis to run menu (10Apr2007)
* Changed conf. interval computation method (22Apr2007)
* Added ListOutput,RunModel and ChangeFontsize buttons (10Oct2007)
* Added Multi-State models (10Oct2007)
** New: see Online book in Help menu **
Proteus
wildlife research consultants
USGS
science for a changing world
Program PRESENCE
<<<< New: see 'Online book' in Help menu >>>>

One alternative to capture-mark-recapture estimation is to present the camera-trap information as the minimum number of individuals present (with standard error) within the survey area, along with supporting this with an occupancy survey that draws on the same camera-trap data. Under this system, the probability of leopards occurring in each of the 100 km^2 blocks surveyed would be reported. MacKenzie et al. (2002) proposed a method for determining the probability of detecting a species or estimating the proportion of an area occupied by a species within appropriate landscape-level sampling units. A series of sites (survey blocks) are surveyed over two successive occasions or by different observers who attempt to detect the targeted species through observing its sign or by recording actual sightings (including captures by automatic cameras). The species may or may not be detected in each block during the survey; a matrix of 1's (presence observed) and zeros (not observed) are used by the Program PRESENCE derive estimates of detection/nondetection. PRESENCE can be downloaded from: http://www.mbr-pwrc.usgs.gov/software/presence.html


Data Input Form
File Edit Simulate Help
rows 39 cols 5 No. Occ/season 5 No. Site Covar 0 No. Sampling Covar 0
Presence/Absence data

data	1-1	1-2	1-3	1-4	1-5
site 1	0	0	0	1	1
site 2	0	1	0	0	0
site 3	0	1	0	0	0
site 4	1	1	1	1	0
site 5	0	0	1	0	0
site 6	0	0	1	0	0

The observer develops a spreadsheet in which rows represent sampling units or sites and columns present different sampling occasions, each of 3-5 days in duration; a "1" indicates that a leopard capture (or observation of fresh sign)occurred during the particular occasion, while a "0" indicates no capture and a "-" is used for missing data (i.e. the site was not sampled on all occasions due to camera malfunction or other factors). PRESENCE does no need equal sample size for all sites. It is also possible to include site-specific covariates and sampling or survey-specific covariates. Examples of site covariates include type of terrain, presence or absence of a key prey species such as ibex, presence or absence of livestock grazing etc. A survey related covariate is typically weather or effort data. The software program will generate an estimate of occupancy (psi) and an estimate of detection probability (p). The former is typically a function of habitat, while the latter reflects environmental conditions such as air temperature.

Basically, Presence/Absence surveys follow the same general procedures described in earlier chapters. The study area is divided into 10 x 10 km survey blocks (100km^2). Researchers then visit the field and sample contiguous blocks of at least 500 km^2 in size, and preferably more 700 – 1,000 km^2 (especially at southern end of the leopard's range near Yemen border. The size of the survey areas can be decreased as one moves northward, since the range becomes more fragmented. Karanth and Nichols (2003) describe sampling strategies for deciding how to proceed with sampling in the case of fragmented ranges.

For examples of a typical camera trapping survey application, see the handouts provided and titled, *Chapter 13: Analyzing camera trap data with PRESENCE*, and *Worked Examples and Exercises in PRESENCE*.

Key Assumptions of Occupancy Surveys: We are applying the "single season model," which assumes that all parameters are constant across sites including detection probability for species, times, locations or sampling methods. However, the model does allow for some movement of individuals between sites. Models are available for examining the assumption that all sites (or samples) are detected with a single probability (1 group, constant p model) and for looking at survey-specific detection probabilities (i.e., p varies over the course of the survey, but is the same for all sites during a particular survey session).

Model assumptions are:

1) Sites are closed to changes in occupancy between sampling occasions
2) No heterogeneity which cannot be explained by covariates (if these are applied)
3) Detection process is independent at each site or survey block

However, the search effort should be similar for each survey block, or at least standardized. Search effort is best expressed as the number of search hours per 100 km^2 of survey block, but could also be recorded as the number of kilometers walked. These would be converted and standardized later to the number of kilometers walked/100 km^2 in the event that watersheds (wades) are used as the standard unit for survey blocks.

Other important assumptions are:

a) The same methods and detection units must be used throughout the survey.
b) Any observations of sign (an indicator of presence) must tally with the current sampling occasion only (i.e., these cannot overlap between sampling intervals).

c) Observers should be given the same training so that their observational abilities and skills can be similar, especially with respect to aging of sign such as feces, tracks and scrapes .
d) Camera traps should be placed in locations with high probability of detecting leopards.

Type of Evidence which can be used for Predicting Presence-Absence:

- Camera traps / captures (2-4 per 100 km^2, deployed at same density across each of the survey blocks – could express these as the # traps/unit area and captures as "yes" or 1 or "no" or 0 or missing data "-".
- Visual sightings and sign (feces, tracks, scrapes etc) (1 or 0 or "-")
- Interviews of local people (as above, but must reflect presence or absence within relevant sampling occasion) (1 or 0 or "-")

The following shows the various possibilities for a 3-occasion detection-nondetection survey

000

- Species is absent on all occasions, or ....
- Species may be is present but was not detected during the survey

111

- Species is present and detected on all three occasions

100

- Species present and detected on the 1st occasion only
- Species present but not detected on next two occasions

Examples of Covariates: Environmental information for assessing factors influencing species use of a site may include such factors as presence or absence of a permanent waterhole, large trees, large-bodied prey (e.g., ibex), while other factors such as the level of human activity, evidence of hunting (bullet cartridges present, human foot prints, presence of traps), and livestock grazing may vary temporally.

Survey Duration, Sampling Interval and Number of Sample Occasions: The suggested protocol for the Arabian leopard (given its rarity, very low visitation rates and the difficulty of finding sign is a survey with repeated occasions every 2 weeks duration (N = up to 6 occasions, depending upon how often camera traps are move over the course of the survey) where the data is provided from camera-traps that are in place for continuous, successive periods.

MacKenzie et al. (2002) recommend a minimum of 3 replicates per site with detection probabilities of >0.5. It is rather doubtful that these can be met in the case of the Arabian leopard, however. It is better to survey more smaller sites than a few large sites. The following website offers some good examples that illustrate the potential of Occupancy modeling: http://www.uvm.edu/envnr/vtcfwru/spreadsheets/abundance/abundance.htm

Data Analysis: The GENPRES software can used to simulate presence/absence data to be input to programs MARK or PRESENCE. It can be used to get an idea of how precise the estimates are for given sample effort or design, or the bias of estimates when heterogeneity exists. A User Manual and numerous exercises are available for the program PRESENCE.

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8.0 APPENDICES

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Appendix 4: Example of CAPTURE Input File

Appendix 1: Preparation for conducting a camera trap survey

1) Preparing Camera Traps for Deployment - Checking Functions & Customization

- ✓ Test each camera to make sure it is working. Test with a "walk-through"
- ✓ Number each camera and sensor unit with a unique identifying number (helps track equipment and keep it tagged to right camera trap station)
- ✓ Install new batteries and memory cards
- ✓ Clean dust or other marks off the lens with lens brush & tissue
- ✓ Check that camera has desired settings
    - Set to desired time period
    - Number of images to be captured at each event
    - Photos are tagged with correct date & time
    - Memory card working correctly
    - Ensure flash cameras are not set in the "red-eye" mode
    - If possible set camera to fixed focal length (reduces latency time)
- ✓ Have the necessary tools to service the sensor and camera in the field
- ✓ Obtain topographic maps for survey area (scale 1:50,000 – 1:100,000)
- ✓ Prepare project-specific forms for camera station set-up and monitoring
- ✓ Names and contact information for key local people

2) List of Equipment and Supplies Needed

- Camera traps - TM 1550 receiver, transmitter, 2 cameras, cables, multi-trigger, camera tripods, batteries & memory cards
- Tape measure (5 m)
- Small voltmeter (for measuring battery voltage)
- Magnetic compass (to help align sensors and record aspect of the camera trap site)
- Phillips screwdriver
- GPS (for recording geographic locations)
- TM1550, camera trap and Canon D-10 operating manuals
- PVC cabling (if rodents an issue)
- Extra memory cards & spare batteries
- Spade or trowel for digging furrow for cables
- Duct tape, string or bungee cords
- Data forms (set-up and activity record), clipboard and field note book
- Black permanent making pen, pencil or ballpoint pen for note taking
- Lens paper, brush and cleaning fluid, plastic ziplock bags for containing the multi-trigger and preventing it was being shorted out by moisture during the rainy season
- Topographic maps of project area (1:50,000 or 1:100,000)
- Daypack for carrying items

- Posts, hammer & related tools if alternative means of installing camera traps are not available
- Laser point (helps orient traps more precisely)

3. Checklist for camera-trap site setup
   - Is the sensor (and camera) set with the correct settings (number of images, camera delay, and in the case of the TM1550, the correct P-value and Camera Alive interval)? Make sure that the sensor has been activated!
   - Has all vegetation been removed from the TM1550 beam or the Reconyx/Bushnell zone of detection in order to prevent false-triggering?
   - If the sensor is facing east or west, change the direction to north (preferred), NW, NE or southerly to prevent the other major source false-triggering.
   - Are all cables of the TM1550 buried (or covered with rocks) in order to prevent them being disturbed by passing animals? If rodents are present, remember to protect the cables in PVC pipe or thick rubber hosing.
   - Is the camera-trap well hidden and camouflaged from human eyes?
   - Has scent or another attractant been placed out?
   - Have you completed the standard data form?
   - Have you obtained the GPS location for the site, so that you or others will know where to find it again?
   - Does the camera contain a notice requesting people not to disturb it?

Appendix 2-A: Summary of TrailMaster 1550, Canon D10 and Data Collector II Operating Instructions

Turning Unit On: Press TIME SET and SET UP at the same time

If Password Activated: Enter correct number one by one using R/0 ADV & confirming with TIME SET. Repeat for the four code digits, in our case 2000.

If First Time, display shows flashing 8.8:8.8 and enter setup mode
Set correct date &, time
Press using R/0 ADV to set value for each DATE & TIME digit (flashing); press TIME SET to advance to next digit

To change values if Date & Time is already set:
Hold down TIME SET for 5 seconds

Setting Beam Sensitivity, Camera Delay and Camera Time Zone:

- Hold TIME SET for 5 seconds
- Use R/0 ADV key to select correct value, then press TIME SET to move to next setting or go through each menu item

Preferred Values are: pulses to miss = P-5; Camera Delay or Cd = 0.1 (6 seconds) with Canon D10 set for single frame mode and a Camera Time [Ct] reset from default of 3.5 secs to 6 or 8 seconds, Camera Alive (CA) value of 1.0 (one hour) and Frame limit to nL or no limit..
For 24 hour operation set ON TIME: hour [0:1n]; minute [1n:00] and OFF TIME set at never [- -:1F]
A time delay of 6 seconds allows the camera's flash to restore itself for the next image.
** make sure the Time Zone is never set at [- -:1n], as this will never allow a picture to be taken!

Set Up Mode: Press to SET UP button. When in "set-up" mode [*S.uP*] will be displayed and the Red Alignment Light (upper one) will flash; it will then go into Active Mode after 4 mins if no buttons are pressed. Use this time to accurately align the transmitter and receiver with the detection spot when you want a photo taken (see manual for details on how the infra-red beam works). Or you can press TIME SET to directly enter event gathering (Active) mode.

Active Mode – This will start data collection: Press the Set UP button, then the Time Set button when you are sure the camera trap is correctly deployed. Otherwise, the unit automatically enters Active Mode after 4 minutes has elapsed.

Reviewing Data: When in Read Out mode, the TM will flash each details of the events which have been recorded and stored in memory, in sequential order.
Follow these steps to review event & capture data

- Press TIME SET (if password-protected, first enter the 4 password numbers as described above)
- Press R/0 ADV to scroll through the events in numerical order (date, followed by the time, an with a . or dot if a photo was taken)
- [thru] will show at the end of records.
- To review data again, press R/0 ADV again

Clearing or Erasing Data: Note, once information is erased, it cannot be retrieved! So be certain before….

- Press SET UP to display [S.uP]
- Press R/0 ADV to display [c lr] ** Press R/O ADV again to keep data!
- Press TIME SET. Now a 0 will be displayed as all data is cleared from memory.

Other Settings: Default are Unit Number, Camera time (set at 3.5), Camera Alive (CA 1.0 or one hour), and Frame Limit (no limit as indicated by nL). See above for settings to be used in the Nimr Project. Hold down the SET UP button for 6 seconds, use TIME SET to advance though menu and R/0 ADV to adjust each value. These have been set by Project Managers, but it is wise to check each.

Unit number (un 0X) – corresponds with the number given each TM1550 set
Camera time (Ct) – set to 6 seconds
Camera Alive (Ca) – set to 1.0 or one hour
Frame limit (L X) – set to no limit (nL)
Passcode – set to 2000

TrailMaster Data Collector II

Stores up to 59,000 events; keeps these data tagged to correct TM 1500 unit number even if the batteries are removed. It enables downloading event data from the TM 1550 and/or uploading to a computer.

Turning On/Off: Press COLLDATA & SEND DATA same time

Check Battery Voltage: Connect TM Data Collector tor cable, then turn unit on. Batteries are OK if [xF:xxun] shows. Change batteries if [bAt] or [Lob] are displayed. Always disconnect cable when not in use, as it drains battery more quickly.

Before attempting to download data: Ensure each TM1550 has been numbered with same identifier as written on the case. Otherwise the TM Data Collector assigns its own, arbitrary number; and 2 Make sure that the TM1550, TM data Collector and computer all have the same baud rate. This should be 9600 baud.

Setting the Baud Rate:

- Connect the Data Collector Cable to the Data Collector unit
- For data collect, hold down COLLDATA for 10 secs -- it displays Baud Rate. Change by using R/O ADV
- For data send, hold down the SEND DATA

Check memory space on Data Collector II: Turn Data collector on. It does sum check [88:88], then displays the number o fails stored [x:F] where is 0-255, then the number of units used [xx:un] when xx is 0-59.

Collecting data from TM 1550 Receiver:

- Connect the Male end of the 9-pin serial cable to The Data Collector II and the female pin to the TM1550.
- Press COLLDATA until [coL!] appears
- Press SETuP on the TM1550 until [Snd?] appears
- Press RO/ADV on the TM1550. [SnD!] is displayed and red light on Data Collector flashes as data is transferred. When finished, the message [thu] will appear on the TM1550 and [cnF!] on the Data collector.
- Repeat this process to error check that the data was transferred correctly, until message [donE] Is displayed.

Clearing All Data from TM1550:

- Press COLL DATA until it shows available unused memory
- Press SEND DATA to show [ALL!] on display, then press SEND DATA again to display [SnD!] and [ALL!] are flashing alternately
- Press SEND DATA so that [Cl r?] and [ALL!] are displayed alternately
- Press R/O OUT to display [Cl r] and [ALL!] are display alternately
- Hold down COLL DATA while unit clears data from the memory bank.

See manual Page 5 for instructions on how to transfer or clear selected data.

Sending Data to PC Computer: Connect 9-pin male connector of TM StatPack to female connector of TM Data Collector II, and other end to your computer's serial port. With StatPack set to File/Import New data:
Press SEND DATA [ALL!] should be displayed (for selected file

Canon Powershot D10 Digital Camera

We recommend setting the operating parameters of the D10 camera as listed below. Consult the manufacturer's operating manual for details;

Set current date & time (prompted on first time battery installation. Otherwise select Tools/Date/Time if this has to be changed)

Format SD card (Menu / select Format, size of card and confirm)

Image Size: Recommended size is M1 = 8 mp, 3264 x 2448, fine setting

In order for the camera to be non-invasive, set sounds (see below), auto-focus assist and red-eye reduction to off:
Select menu, then the camera icon:

AF Frame - "Center" (place camera to capture animal at center of frame)
Servo AF - OFF
AF-Point Zoom - OFF (after camera set at desired zoom level if necessary)
AF-assist beam - Probably best set to OFF, as it will almost certain trouble shy species like nimr (for details see below, under manual focus)
Blink Detection (Red-eye) - set to OFF

Flash settings:

Red-eye correction - set to OFF
Red-Eye Lamp - set to OFF

Other Settings:

i-Contrast - OFF
Review - set at 2-4 secs after set-up completed
Review Info - On or OFF as desired
Disp Overlay - OFF
IS mode - Note the Continuous setting has the camera shooting an image every 1.1 secs under manual (finger) shutter control; The TM settings above ensures continuous images every , which is too fast for the flash capacitor to recycle its power; since nimr will very likely come at night or later afternoon in low light, we will need the flash to properly light the target area. Therefore set the low there likely too
Date Stamp - set to Date & Time (facilitates matching images & events)

Sounds & Volume adjustments made under "Tools" icon

Mute - set to OFF (Use ON if you want to draw animal's attention)
- If mute is off, you can select amount of volume –

LCD Brightness - reduce to ½
File Numbering: - Continuous (remember to give each SD memory card a number and keep it associated with same camera for ease of data management.

Flash Mode: Controlled using right center control button on the back of camera. Leave setting on

automatic, or for faster picture taking set to “always on. Do Not set on slow synchro.

Recommended Battery-saving Functions:

Set LCD brightness to -1/2 -

Review information = OFF (since no-one is present after set-up, no review of the images being captured is required. This greatly increases battery life).

Display review time can also be reduced to 10 or 30 secs

Other Options for reducing time needed to take a picture:

Set in Program Mode

Set focus to manual

Advise setting camera on Program (rather than Auto mode)

Use ASA 200 (good compromise between speed and low light conditions)

Metering mode = center-weighted average (selection Function button, the “dot+-” and pick)

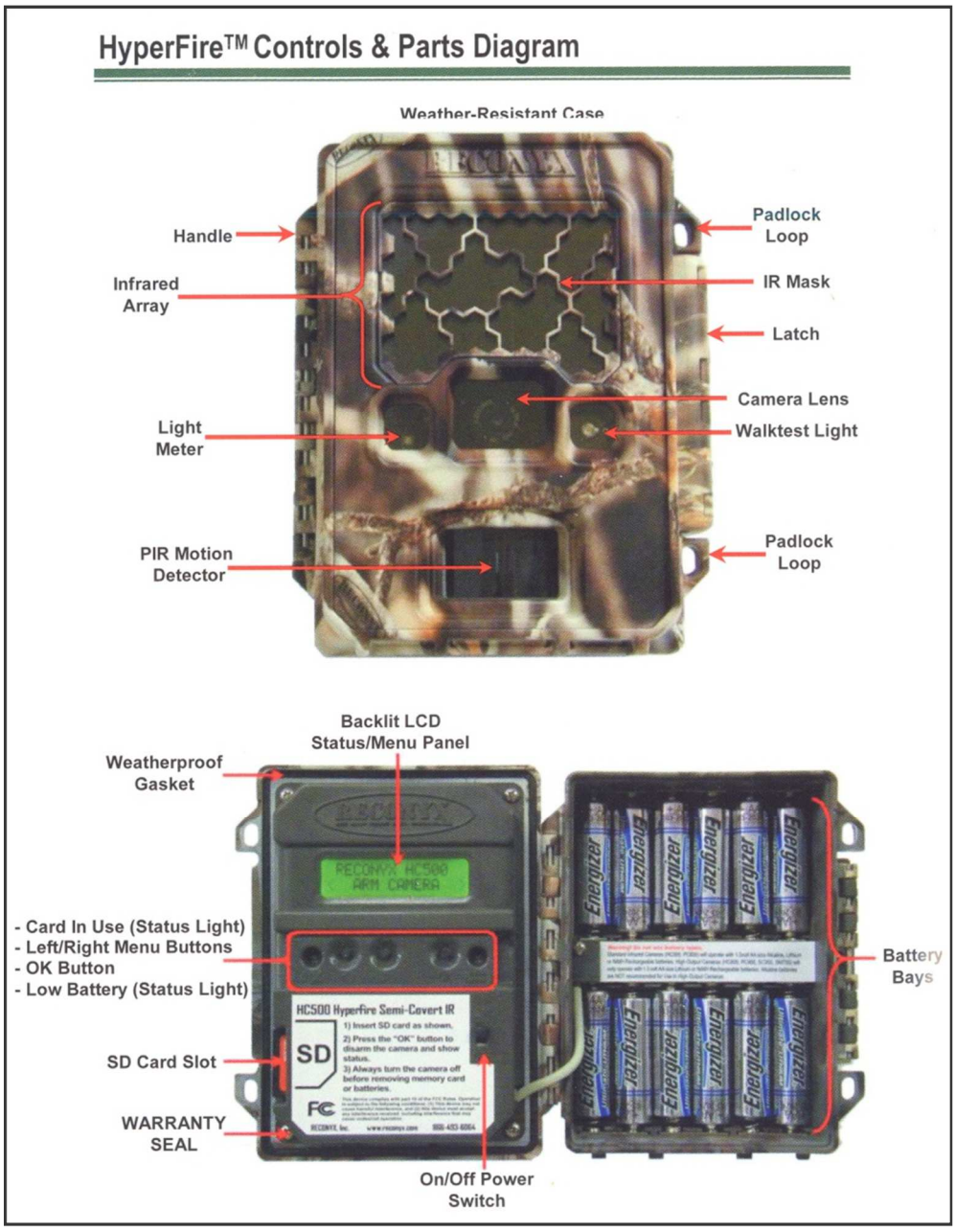
Check for exposure, and if necessary adjust (press +/- button)

Language can be set to English or Arabic.

Adjust white balance (only if images have color shift – see manual)

Appendix 2-B: Summary of Reconyx and Bushnell Trophy Cam Operating Instructions

1) Reconyx HC500 Low-Glow Passive InfraRed Camera-Trap

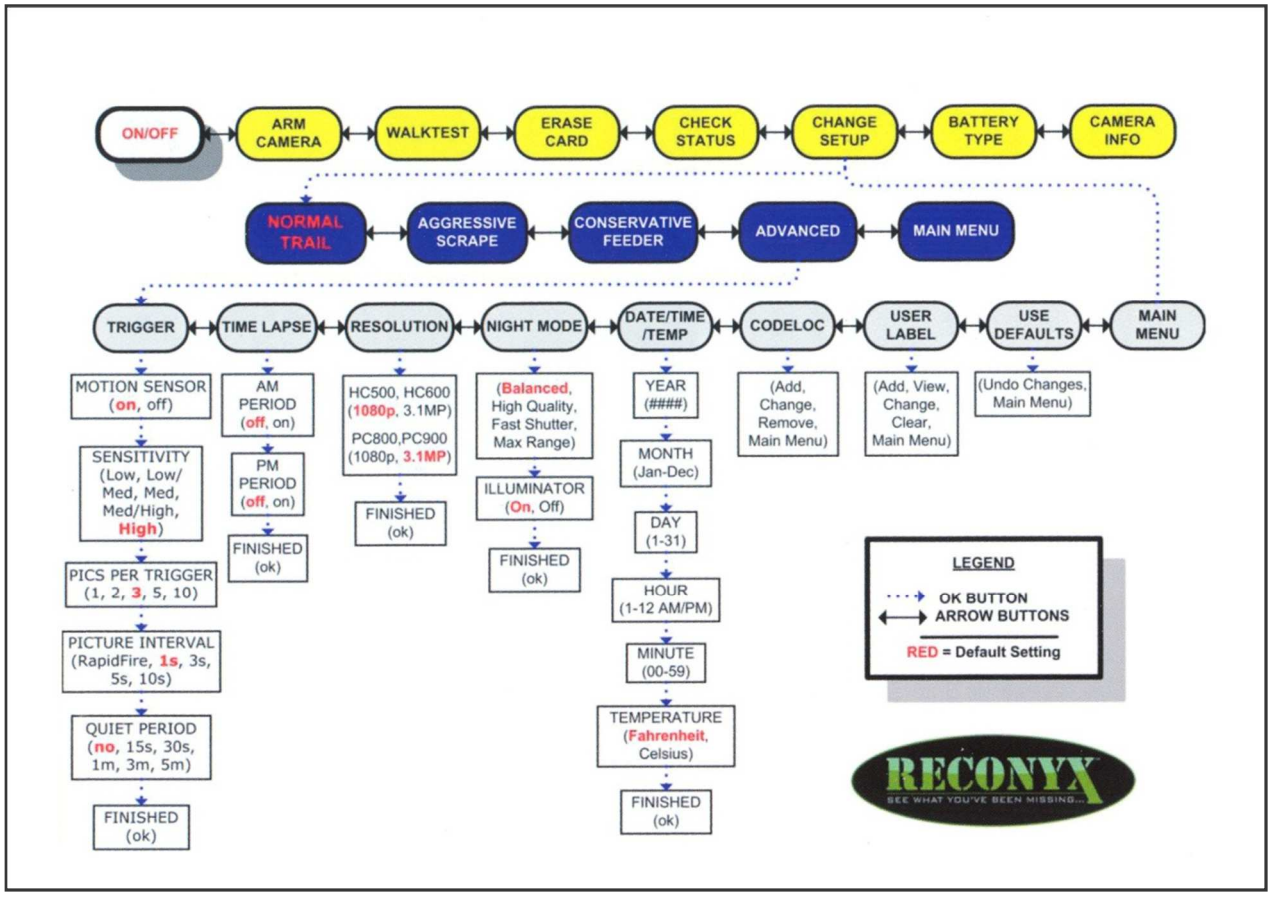


The Reconyx takes images of 1080 HD or 3.1megapixel color by day and monochrome by night. It has a trigger speed of 1/5 of a second, can take up to 2 frames per second, and has a SD card capacity of up to 32Gb. Thee nighttime illumination range is 15 meters. It can operate on three types of batteries: regular AA Alkaline, rechargeable NIMH and Lithium. While AA alkaline cells can be used, but the Energizer Lithium Ultimate battery provides the longest life, as well as working better in heat and cold compared to regular alkaline batteries.

Insert the SD (Secure Digital™) memory card into the slow as shown on the diagram above. Unlike Bushnell, the card needs to be formatted on a computer first using its card reader and the FAT32 file system.

Always power OFF before insetting or removing a SD card from the camera's memory slot. Turn unit on. Camera reads the card & reports number of images taken and remaining battery power (in percent).

The Reconyx has a three-level menu, as shown in the following diagram.



Select Change Setup (Level 1) and Advanced to make any changes to way the camera functions, such as triggering, data/time, image resolution, night mode, user label etc. In each case press the forward advance button to search, select and set the following functions in order:

Battery Type - Press OK and then scroll through selection options, Then select currently installed battery type by pressing OK again. Remember: Do not mix batteries!

Trigger:

ON

Sensitivity = high

Pictures per trigger = set to 1 or 3 (max = 3 taken per movement/triggering)

Picture interval (Time between each event) = suggest setting this at 5 or 10 secs

Quite Period – No delay (OK to return to remaining options under Level 3)

Time Lapse = leave OFF

Resolution = 1080p

Night mode = use Balanced, Illuminator = ON (may have to turn off for leopard!

Date-Time/Temp: -- change these if they are not correctly set, in order year, month, day, hour, minute and temperature. Alter each desired item, confirm with OK. This returns you to Level 2 or the QuickSet Options. Then select "Main Menu" to get you back to Level 1 (required for arming the camera). Codeloc – 4 digit Security Code or Password

User Label – allows name (up to 16 characters) to be added to each photo taken, which is useful for identify the site where the image was captured

User Defaults – cancels all user applied settings and returns to default parameters

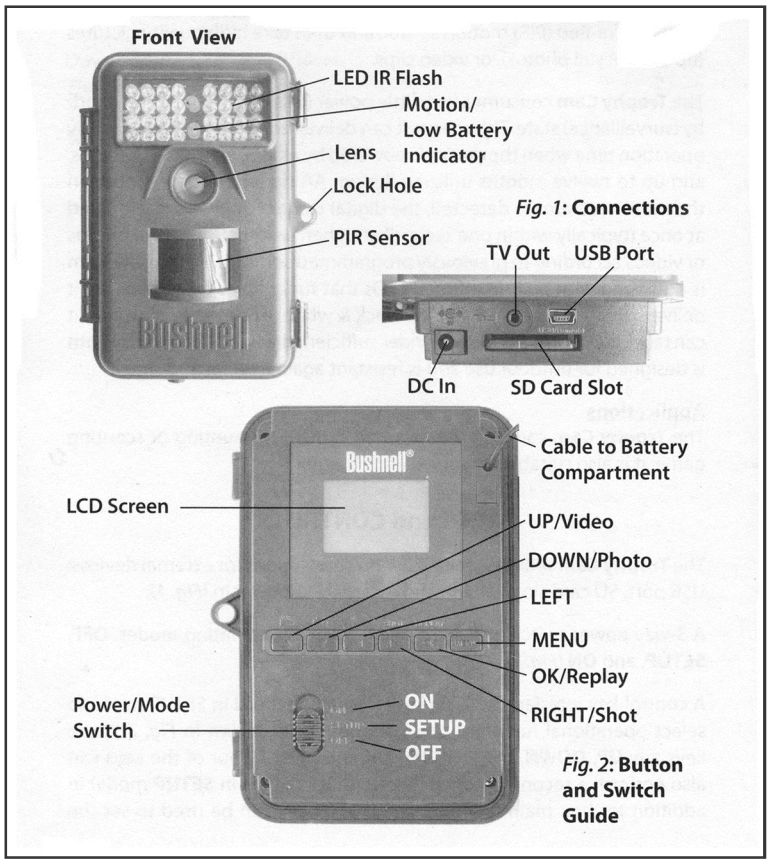
Use Main Menu to return to levels 1 & 2.

Number of Pictures Taken: Switch camera on, and allow it to run through its initialization (the "Read Card" message is displayed on the LCD). Then press the > or < buttons until < check status > is displayed, press OK, to get the number of pictures , % of card filled and % of battery power remaining.

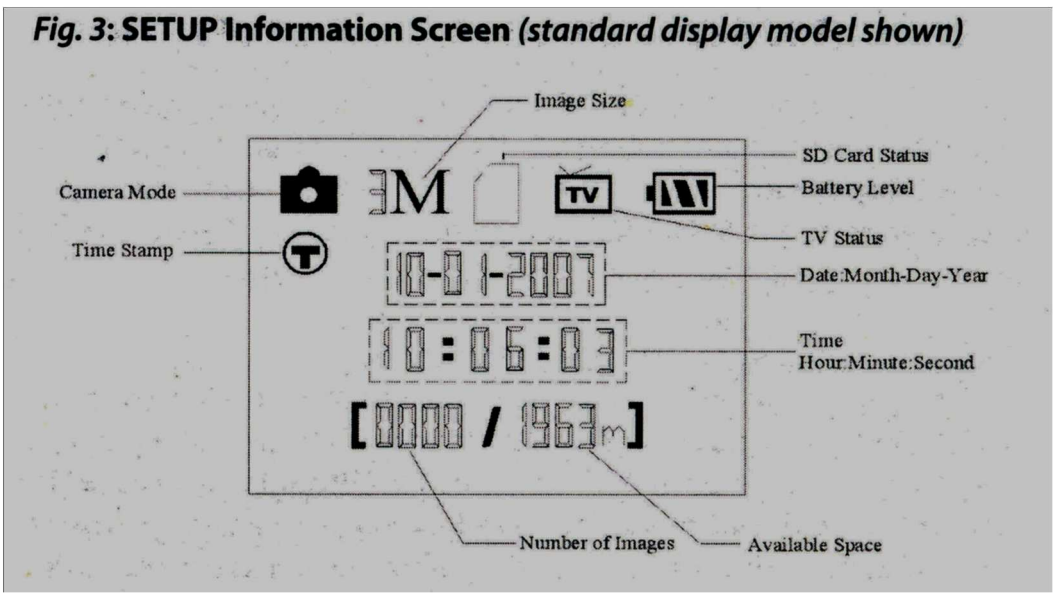
Test IR Sensor: To test the zone of detection, press WalkTest. The red-light will blink every time the sensor detect motion, enabling you to aim it as desired. Note that the camera will remain in test mode until the OK button is pressed again. The camera will self-arm after a period of 2 minutes in which it detects no motion.

If the camera is already correctly placed, selected Arm Camera option and press OK to put in into Active mode immediately.

2) Bushnell Trophy Cam (2 models, camouflaged and non-camouflage are the same operationally)



The Bushnell has a 5 megapixel image sensor, a 50° field of view lns and a infrared lighting range of 12-15 meters. Available picture sizes are 3264x2448 (8MP), 2560x1920 (5MP) and 2048x1536 (3MP). The 8MP is slower, which is why we recommend using 5MP. The maximum SD card capacity is 16GB. It has a response time (trigger speed) of 1.38 seconds. It uses 8 AA batteries; the Energizer Lithium Ultimate is also recommended for their longer life and better performance at both hot and cold temperatures. However, NiMH batteries can be used in the Bushnell camera-trap.



Always insert or remove SD card **only** when the camera is switched OFF.

Switch camera ON and place in SETUP mode. Use Down arrow to put into still photo mode, UP arrow for video. Set the following parameters for Photos (ignore settings related to Video, including video size, length or TV output):

Image Size – suggest 5 or 8mp
Capture number (number o images to capture for each detected movement, 1-3) = 2
Interval camera waits for next response (15 secs – 1 min) = 15 secs
Sensor level = High
Format – use to format the card for first time use
Time Stamp = On (quick reference to data & time when viewing images, though this information should be stored with image or file's meta-data)
Set Clock – Use for setting year, month, hour and minute.
Default Set – returns all settings to the default mode

To Test Camera Alignment:

Place camera in setup mode. Red light blinks whenever it detects motion

To Set Camera in Active Mode:

Place switch to the ON position, and close the case. The camera red lights blinks for 10 seconds after which it starts recording events – so be quick!

When Checking the camera: Promptly open the back (without moving the camera if possible) and switch the unit OFF. Place switch on setup to determine how many frames have been taken since the memory card was last erased clean.

Video Settings: Video length (30fps) can be from 1 second to 60m seconds with three resolutions: 720x480; 640x480; and 320x240.

Triggering interval 1 second to 60 minutes (programmable)

Operating temperature: -20°C to +60°C and humdity 5-90%

Appendix 3 – A: Form No 1 - Camera Trap Site Characteristics

Province / Sub-Province: _____ ***Form Number (Linked to):*** _____
Survey Area: _____ **Site ID or Name:** _____
Name of Person(s): _____ **Date (Day/Month/Yr):** _____
GPS Lat/Long: _____ **Elevation (m):** _____
Sensor Type / ID: _____ **Camera ID's:** _____ **and** _____ **Multitrigger ID:** _____

Site Feature Attracting Leopard:
(Circle those items best describing the site)
Travel Corridor
Rock Scent
Scrape Site
Kill
Trail (Path)
Waterhole
Livestock enclosure
Other (describe):

Trail Type: (circle only one)
Well defined
Moderately well defined
Poorly defined or hard to see

3. Dominant Substrate: (circle only one)
Rocky
Gravelly
Sandy
Fine grained: (fine silt, loam or dust producing very good pugmarks)

2. Leopard Sign Present: (Record all sign present, including number & age within 10 m)
Pugmarks (spoor or tracks):
Size (length x diameter):
Age Class:

Scrapes:
Number present:
Size (width x length):
Age Classes:

Rock-scent:
Number present:
Age Classes:

Feces: __ Collected for DNA (Sample #_____)
Number present:
Size (length x diameter):
Age Class:

4. Other Carnivore & Prey Sign: (List species & sign type, describe kill site):

5. Position on slope:
☐ Lower ☐ Middle ☐ Upper

6. Habitat ruggedness: (See definition & circle items best describing the site)
☐ Cliff ☐ Broken ☐ Very broken
☐ Rolling ☐ Flat ☐ Other

7. Topographic Feature:
☐ Cliff ☐ Ridgeline ☐ Hill-slope
☐ Valley Floor ☐ Drainage/Wadi ☐ Boulder Field

8. Vegetation Type:
☐ Barren ☐ Grassland ☐ Shrubland
☐ Woodland ☐ Cropland / fallow field ☐ Other
Tree Species: _____

9. Rangeland (Grazing) Use:
Seasonal: ☐ Summer ☐ Winter
Non-seasonal: ☐ Year-round Use ☐ No Use

10. Human Presence (including herders):
☐ High ☐ Moderate ☐ Low ☐ None
Comments: _____

Draw diagram of the site: (include sensor & camera locations with aspect, height). Complete DNA form.

Description and Codes

1. Sensor Type: It is important to keep a careful record of sensor and camera numbers in order to track data by both site, camera & photograph number, and to make it easier to maintain the survey database if sensors and/or cameras are shifted from one site to another. On the Set-up form (Form No 1) record only the units first deployed at the site. The Site Visitation Forms (# 2) should be used to keep track of images, sensor and camera numbers throughout the survey.

TrailMaster 1500 or 1550	TM
Reconyx	RE
Bushnell Trophy Cam	BT

Record the sensor and camera numbers given to each item. Note you need to record camera numbers for the TrailMaster, since these can be mixed between sensors. All other cameras form part of the sensor unit, so simply record that each unit's number. Only the TM will have a multi-trigger ID number.

2. Leopard Sign (probably not relevant in Saudi Arabia)

Scrape Site

Non–relic	0	Usually only one scrape is present at the site or all the scrapes (and feces) are about the same age. No evidence of repeated use.
Relic	1	Usually there are numerous (3–10) scrapes present of various ages. Due to remarking, some or most scrapes have a sculptured appearance. Feces of many different ages may also be present.

Type of sign present at site:

Scrape	SC	Scrape made by a leopard or other felid.
Scratch (canid only)	SR	Scratch made by a canid.
Feces (scat)	FE	Scat or dropping.
Urine	UR	Urination mark.
Scent spray	RC	Scent mark.
Claw rake	CL	Claw mark made on a tree trunk or rock face and left by a felid
Pugmark	PU	Footprint impression or track

Sign age or visibility (by type of sign present): *Aging needs to be validated for the Arabian Leopard*

Scrape

Very old	0	Extensive weathering and disintegration, scrape features poorly defined, often with vegetation growth in the depression and on the pile (age = at least 3 to 6 months).
Old	1	Moderate weathering and disintegration, with the scrape showing a rounded form, occasionally with vegetation in the depression or on the pile (age = several months or more).
Fresh	2	Slight weathering. Scrape has a well–defined form with "sharp" edges, is easily recognizable, and has no new vegetation growing in the scrape depression or pile (age = 1 to 4 weeks).
Very fresh	3	Little or no weathering has occurred, so that the scrape has a very sharp and "clean" form, is very easily recognizable, and has no vegetation in its depression or pile. Sand or gravelly material may cover some vegetation, causing it to "bend-down". Other ephemeral sign such as tracks or urine may be observed, while scats deposited at the same time are obviously still fresh or very fresh (age = less than 1 week).

Pugmark (Spoor, tracks)

Old	0	Pugmark is very poorly defined, with an obviously "weathered" appearance (more than 2 weeks old).
Fresh	1	Pugmark has sharply defined edges and shape (several days, but less than one week old).
Very fresh	2	Pugmark is very fresh, showing fine surface details and having a very sharp edge (made less than 24 hours previously).

Feces

Old	0	Scat is mottled and cracked, with a hard, dull surface and dry interior (several weeks to several months of age).

Fresh	1	Scat is odoriferous and "fresh-looking", with a glossy, sheen inside (more than 2 days but less than 10 days of age).
Very fresh	2	Scat is still wet outside and moist inside (no older than 2 days).

Scent-sprayed Rocks

None	0	No detectable odor (more than 3 months old).
Slight	1	Odor is just detectable.
Moderate	2	Odor is readily detectable.
Strong	3	Odor is unmistakable.
Very strong	4	Odor is very strong (can be detected from 25 cm or more away; less than several weeks old).

3. Substrate type:

Rock	1	Ground surface consists largely of rock.
Gravelly soil	2	Mixture of small pebbles (particle diameter more than 2 mm) and soil.
Sandy soil	3	Sandy appearances with particles having a diameter of less than 2 mm.
Fine or silty soil	4	Soil consists of fine or very fine particles (clay, silt, and dust).
Snow	5	Snow dominates.
Vegetation	6	Vegetation dominates.

4. Other Carnivore and prey Sign: List any other carnivore sign found within 10 m of the sites, such as wolf or fox, along with type of sign (feces or scat, tracks etc) and its age (using same categories as leopard). Also write down any evidence that the prey species of leopard (e.g., ibex, hare, baboon etc) are utilizing the area, such as fecal pellets, tracks, and bedding sites as well as signs of browsing on the vegetation. For feces and tracks use the same age codes as leopard.

For bedding sites (i.e. places where an ungulate has lain down to rest) can be aged using such combined evidence from the distinctiveness of impressions in the sand where the animal lay, freshness of most recent pellet groups or track age. Use the 3 categories of old, fresh and very fresh, with same categories for age, where

Old or very old = 0 (sign more than a 7-10 days old, up to 6 months or more)
Fresh = 1 (use of bed from several days to a week or about 10 days ago)
Very Fresh = 2 (bed used within the last day or so

5. Position on Slope: Draw an imaginary line from the base of a mountain and divide it into 3 equal parts

Lower	Section located in lowest 1/3 of mountain slope
Middle	Section located in middle portion of mountain slope
Upper	Section located in upper 1/3 of mountain slope

6. Habitat Ruggedness: Describes the nature of the land surface around the camera trap site, and within a distance of 50 m

Cliff	CLF	Terrain at site is very precipitous (slope more than 50°)
Broken gullies	BR	Terrain broken or moderately broken by cliffs, rocky outcrops, ravines, and
Very broken	VBR	Terrain heavily broken by irregular slopes, rocky outcrops, and gullies
Rolling fan)	ROL	Terrain has a relatively smooth land surface (e.g., rolling hills or alluvial
Flat	FLA	Terrain forms a level surface (e.g., plain or valley floor)
Other	OTH	Other terrain type; indicate in note

7. Local Topographic Feature:

Cliff	CLF	Terrain at site is very precipitous (slope more than 50°)
Ridgeline	RID	Pointed land-feature that runs up the side or along the crest of a mountain.
Hill-slope	HIL	Place along the side or slopes of a mountain or hill
Valley Floor	VAL	Bottom of a valley
Stream Bed	STR	Seasonal or permanent drainage, including a stream or river-bed
Scree/Boulders	SBO	Loss gravel, rocks and boulders, often at the bottom of a cliff or steep slope (also known as talus or boulder field).

The best sites for camera traps are along well-defined trails at the base of cliffs, along crest-line ridges with saddles and low passes between adjacent valleys, near promontories (point land offering good view of the land

below), or along shoulder ridges that offer a natural pathway from valley floor to a mountain preferably with many large boulders and promontory points along its length. The narrower the ridge, the more likely leopards are to mark along the feature.

8. Vegetation type:

Barren	BAR	Less than 10% of the ground has vegetation cover
Grassland	GRA	Dominant vegetation is grassland
Shrubland	SHR	Dominant vegetation consists of shrubs
Woodland	WOO	Dominated by open trees and savanna
Forest	FOR	Tree cover exceeds 30%
Crop/fallow field	CRO	Cultivated or fallow land
Other	OTH	Other habitat type such as field (describe)

9. Rangeland (grazing) Use:

Seasonal or winter)	1	Area grazed seasonally by livestock (indicate if during the spring, summer
Year-round grazing	2	Area grazed throughout the year by livestock
No Use	0	Area is not grazed by livestock

10. Human use:

High impact	3	Widespread evidence of poaching or other disturbances to wildlife in the area (e.g. presence of traps, regular reports of hunting, pervasive depletion of the prey base, intense competition for forage from livestock, etc)
Moderate impact	2	Moderate level of disturbance by people
Low impact	1	Human disturbance is present, but the impacts of such activities are judged to be minimal and not currently a threat to leopards
No human impact	0	People rarely visit area, neither they do not hunt or disturb local wildlife: impact is thus negligible.

Appendix 3 – B: Form No 2 - Camera Trap Site Monitoring

Location: _____Form: _____ of _____
Site No.: _____ Previous Location: _____SD Card No: ____ & _____

Setup Date: _____ Setup Time: _____ Date Removed: _____

DATE CHECKED (DDMMYY)	**NAME OF PERSON(S) CHECKING**	**FRAME & EVENTS**	**TYPE OF SIGN PRESENT (See 1, 2,3)**	**SIGN AGE(S) (See 3)**	**PUGMARK / SCAT MEASUREMENT & HAIR / SCAT COLLECTION # (See 5)**	**COMMENTS** (including replaced SD card number & capacity type, battery level, camera malfunction, etc)

Sensor & Camera Settings: (see operating instructions for details; *Note under comments if these are changed later*)

TrailMaster: _____P=_____, cd=_____, Record Times:Time 1=_____to_____, Time 2=_____to_____
Reconyx: _____ □ Continuous □ Day Only □ Night Only No Frames/event: _____ Camera Time Delay: _____
Bushnell: _____□ Continuous □ Day □ Night No Frames/event: _____Camera Time Delay: _____
Sensor Placement: Aspect _____Height (cm) :_____ Camera # 1 Dist to Trail:_____ Camera # 2:_____
Camera Settings: Speed (ASA): _____ Mode: □ Auto □ Program Sound: □ On □ Off
File numbering: □ Continuous □ Auto Reset mode **Image numbers**: Start: _____ Ending _____
Other Notes:

Appendix 4: Example of CAPTURE Input File

Abstracted from: Jackson, Rodney M., Jerry D. Roe, Rinchen Wangchuk and Don O. Hunter. 2005. Surveying Snow Leopard Populations with Emphasis on Camera Trapping: A Handbook. The Snow Leopard Conservancy, Sonoma, California (73 pages) (available for download: http://snowleopardconservancy.org/publications.htm).

Information from the Capture History (Table 4, Chapter 4) must be entered into an ASCII file in the format shown below for analysis by CAPTURE. These data represent the capture histories for 6 snow leopards (labeled 1 through 6), for 9 trapping occasions of 5 days each. Thus, Snow Leopard # 1, an adult male was photographed during 7 of the 9 sampling occasions, while # 6 was only captured once by a camera trap, and then during the last trapping occasion. The input file should be prepared using an ASCII text editor such as Microsoft Notepad.

Capture files can be entered interactively according to the screen prompts provided, or via "batch" files. See the CAPTURE manual for details, which can be downloaded from: http://www.mbr-pwrc.usgs.gov/software/

The file for capture history presented in Table 4 looks as follows(the terms are explained in more detail below):

```
title title='Snow Leopard Survey Example'
task read captures occasions=9 x matrix
format='(a5, 4x,9f1.0)'
read input data
1 AdM     111011011
2 AdF     011100011
3 Sub?    011010010
4 SubM    000100001
5 AdF     100010000
6 Ad?     000000001
task closure test occasions=1-9
task model selection occasions=1-9
task population estimate occasions=1-9 NULL JACKKNIFE REMOVAL ZIPPEN DARROCH
task population estimate occasions=1-9 MT-CH MH-CH MTH-CH
```

title='Snow Leopard Survey Example' (*Title you give to the survey*)

task read captures occasions=9 x matrix (*Refers to x matrix format of the data, in this case having 9 sampling occasions for each animal)*

format='(a5,4x,9f1.0)' (*Format information needed by software to process the data, where*

- a5 indicates the number of characters in the ID;
- 4x the number of spaces between the ID and data, which the program will skip over
- 9 the number of trapping occasions
- f1.0 indicates single integer or data without any decimal points where 1 = captured during sample occasion, or 0 = not captured during sample occasion

read input data (*PLACE DATA HERE* – take special care to ensure it is formatted corrected. This is best done in a text editor that adds no special formatting and records characters in their simple ASCII format)

task closure test occasions=1-9 (*This instructs CAPTURE to run the closure test for all occasions*)

task model selection occasions=1-9 (*This confirms population estimates will be based on all sampling occasions*)

task population estimate occasions=1-9 NULL JACKKNIFE REMOVAL ZIPPEN DARROCH

(*This instructs CAPTURE to estimate populations of the listed models: Null Model (M_0), Heterogeneity Model (M_h), Trap Response or Removal Model (M_b), and the Schnabel Model (M_t) respectively*)

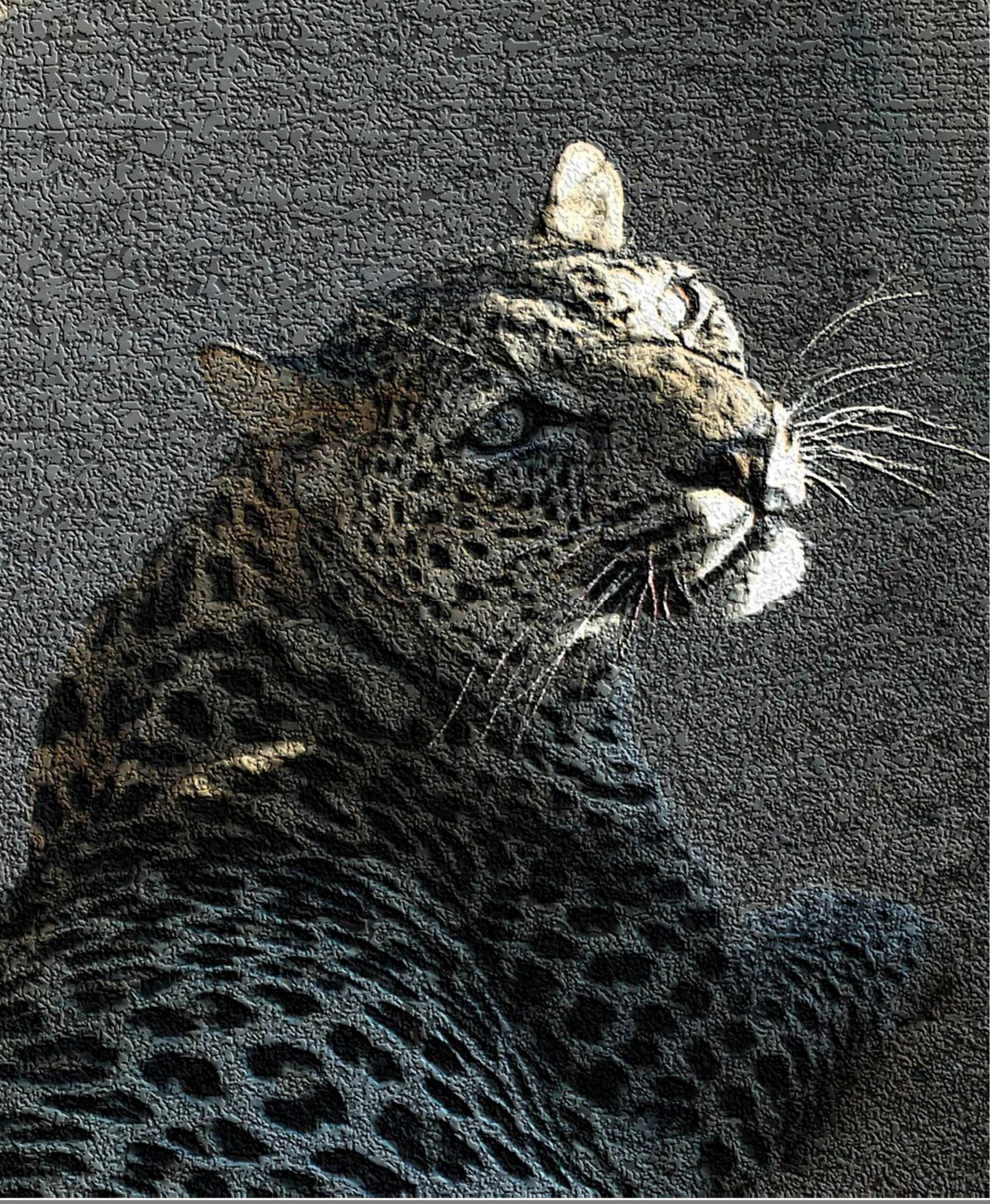
task population estimate occasions=1-9 MT-CH MH-CH MTH-CH

(*This instructs Capture to estimate the three models without population estimators, namely Time variation in captures or recaptures (M_{tb}), Time and Heterogeneity Model (M_{th}), and the All Effects Model (M_{tbh})*)

An alternative would be the statement "Task population estimate ALL" To get the most appropriate model, the command would be "Task population estimate APPROPRIATE"

See CAPTURE User's Guide for Detailed instructions.

The website site operated by the USGS allows one to run data interactively, without downloading and installing the CAPTURE software. Visit: http://www.mbr-pwrc.usgs.gov/software/capture.html



National Wildlife Research Center (NWRC)

PO Box 1086, Taif, Saudi Arabia

Tel. Office: +966-2-7455188, Fax: +966-2-7455176.

www.nwrc.gov.sa